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Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Link to publication from Aalborg University

Citation for published version (APA):
Vistisen, P. (2016). *Sketching with animation: using animation to portray fictional realities – aimed at becoming Factual*. (1 ed.) Aalborg Universitetsforlag. e-bøger fra InDiMedia No. 4

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Peter Vistisen

e-books from
InDiMedia 4

AALBORG UNIVERSITY PRESS

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WITH ANIMATION

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PETER VISTISEN

Sketching With Animation: Using Animation to Portray Fictional Realities – Aimed at Becoming Factual

By Peter Vistisen

Book series: e-books from InDiMedia (Center for Interactive Digital Media & Experience Design) – No. 4

Design and layout: Peter Vistisen
ISBN: 978-87-7112-609-9   ISSN: 2245-3180

Published by:
Aalborg University Press, Skjernvej 4A, 2nd floor 9220 Aalborg
Phone: +45 99407140 aauf@forlag.aau.dk www.forlag.aau.dk

An electronic edition of the publication can be downloaded under open access from: *http://aauforlag.dk/Shop/skriftserier/e-boeger-fra-center-for-interaktive-digitale-m/default.aspx*

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ABOUT THE AUTHOR

Peter Vistisen is assistant professor at Center for Interactive Digital Media & Experience Design at Aalborg University. After receiving his Master in Interactive Digital Media, from Aalborg University he immediately started working as a part-time teacher, and researcher at Aalborg University, as well as freelance interaction designer doing digital design work for various clients. His research interest is design thinking, especially in regard to strategic design possibilities with digital technologies based on a user-centred design approach. He publishes on topics like 'strategic design', 'design epistemology', 'cross media', 'interaction design', and 'sketching' in international journals, and at international conferences.

During the past 6 years, Peter has been teaching and supervising bachelor and master students at Aalborg University, and at University College Nordjylland. He has disseminated the contributions of his research for both academic peers and industry stakeholders.

In this book, the major findings from his PhD study is presented in a more didactic manner - providing lessons learned for both interaction design students and practitioners interested in using animation as a sketching approach to explore concept designs of non-idiomatic digital technologies.

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INTRODUCTION

This book offers a contribution to the theory, method and techniques involved in the use of animation as a tool for temporal design sketching. Lifted from its traditional role as a genre of entertainment and art and reframed in the design domain, animation offers support during the early phases of exploring and assessing the potential of new and emerging digital technologies. This approach is relatively new and has been touched upon by few academic contributions in the past. Thus, the aim of the text is not to promote a claim that sketching with animation is an inherently new phenomenon. Instead, the aim is to present a range of analytical arguments and experimental results that indicate the need for a systematic approach to realising the potential of animation within design sketching. This will establish the foundation for what we label **animation-based sketching**.

The books is based on a three long PhD-study developing and experimenting with animation as a sketching capacity in design, in which an early manuscript of this book formed part of the theoretical and experimental contribution. The research project began with a request by the Danish innovation network 'Animation Hub', sponsored by the Danish Agency for Science Technology and Innovation. Animation Hub is managed and administered by a consortium consisting of the universities of Aalborg, Aarhus, and Copenhagen, as well as the Animation Workshop in Viborg. The initial ambition of the network was to further the use of what they labeled 'functional animation' - that is

> *"Animation aimed at specific purposes outside the domain of entertainment"*
> (en.animationhub.dk).

This definition was inspired by oral presentations delivered by the head of school of the Animation Workshop College in Viborg, Morten Thorning. Thorning provided an overview of various ways in which animation could be valuable beyond the realms of entertainment and art. These new applications included visualising science, news, health care information, data visualisation and graphical facilitation (Thorning 2014). It was evident that functional animation was a very broad concept, embracing everything from animation used to create documentary style communication to animations used as components in the user interface of computers.

Into this arena came an ambition to explore how animation could be utilised to facilitate the early phases of innovation projects. As with any relatively uncharted territory, many questions have arisen about definitions, practices, viability, and technical issues . This book aims to address some of these questions.

RESEARCHING ANIMATION-BASED SKETCHING

When exploring possible future states of the world, the archetypical activity in design is broadly acknowledged as sketching (e.g. Jones 1992, Fallman 2003, Buxton 2010). Sketching, often understood as using pen & paper or other 'drawing materials' to think with and communicate with, has been subject to many intriguing studies. As we saw above, some have even gone to the extent of talking about sketching as something, which can also be done with temporal medium like video, or in 3D with clay or foam. Design researcher Bill Buxton popularised this view on sketching, in the community of human-computer interaction, arguing for the broad width of sketching:

> *"How a technique is used is the ultimate determinant of whether one is sketching or prototyping."*
>
> Buxton, 2010

Buxton's idea is that sketching is not a specific technique, but rather a specific way of acting - and in that way also a special way of thinking. Buxton is not alone in seeing sketching as sort of a mindset, since some of the principal studies on design sketching shows how sketching is an expressive capacity enabling the reflective practice of design to unfold (e.g. Goldschmidt 1994, Bilda & Demirkan 2003, Wu et al 2013, Suwa et al 1999). Thus, sketching is considered to be more than pen & paper, and more than just a technique.

However, only few studies examine the use of animation as an extended sketching approach, and those that do have not systematised and arranged the broad palette of available techniques and approaches in all their complexity.

This is somewhat strange since animation and, to some degree, traditional video have a range of qualities which make them ideal for exploring interactions, services, and user experience designs which occur through time, and with new (imagined) technologies.

Animation researcher Ralph Stephenson has distinguished between mimetic film and animation in a rather more precise manner.

> *"The key difference between animations and classic film is that animation offers the producer the ability to have near full control of the material matter, and is not constrained from the context of the physical world which the video media is limited to."*
>
> Stephenson, 1973

Stephenson suggest that the illusion of life potentially involves much more than making an animated figure come to life and telling a story or creating an artistic impression. Instead, animation offers us the ability to free ourselves from the contraints of the physical world *as it is* and to imagine contexts, situations, and designed products that do not yet exist in reality. In addition, it allows us to explore their dynamics and temporal features.

AN EXPANDED VIEW ON AN EXISTING PHENOMENON

This book did not discover animation as design material. As we will show, many previous contributions have paved the way by indicating both the potential and the pitfalls of using animation in the early design process. Not all of these are strict academic research contributions: some are intriguing examples of companies and organisation experimenting with animation in their own design processes. Examples of the use of animation in exploring the design of new technologies is not new. In 1987, Apple's Knowledge Navigator videos made use of animation to portray the future use of technologies then only in the R&D stage of their development (Buxton 2010). Other examples are provided by Tognazzini (1995) and Nokia (Ylirisky & Buur 2007), and a programme of using animation in big budget visions has existed for at least 30 years. In recent years, companies as diverse as Jaguar, Google, and IKEA have utilised animation to communicate concepts. The rise of social media such as Facebook, Youtube and Vimeo has given rise to a steadily increasing amount of industry animation-based sketching reaching the public. Using short videos which often employ animation to represent an idea for the future use of given technology or a novel interaction between existing technologies, companies generate buzz and gain attention before the product has even been developed into a technical prototype.

For example, prior to the International Auto Show in April 2014, Jaguar teased their new R&D project 'Discovery Vision Concept' for Land Rover SUV cars. The concept used cameras located in the grille of the SUV to project an image of the terrain ahead on the Head-Up Display of the vehicle, making the hood virtually transparent to make it much easier to navigate up-close obstacles such as large rocks and narrow tracks. All the technology did exist, but no functional road-ready car prototype existed at the time. To overcome this obstacle, on April 8th Jaguar launched a Youtube video which was labeled a 'Virtual Prototype in Testing' (Land Rover, 2014).

In essence however, what was presented was not a prototype but an edited video which used animation to emulate the behaviour of the digital transparency technology in a scenario employing a natural discourse to show the technology in use.

Figure 1: Stills from the Jaguar 'Discovery Vision' concept video, showing the live footage of a car approaching a hill. Suddenly the front panel of the car is made transparent through animation, further animating how parts of the car would remain visible, while other parts become fully transparent to let the driver assess the obstacles below the car.

Jaguar disclosed little about the intent behind this video, but their launch on Youtube prior to the International Auto Show may provide some indications. In its first day on Youtube, the video was viewed 272.574 times, and several media outlets picked up the story about the concept (Ireson 2014, George 2014). Thus, the sketch undoubtedly served as an effective hype generator for the Auto Show and as a piece of viral marketing for Jaguar. But there was more to it than mere marketing. What the video also accomplished was to explain and show the natural potential of having an SUV with a transparent front shield, thus suspending disbelief about this new type of technology. In this regard, the video might have been made as a piece of marketing, but it also accomplished the important function of gathering feedback from the potential users of the future technology. This feedback was useable in further development of the concept. In the year since its first release on Youtube, the video has been viewed more than 2 million times.

What this short example shows us is that there is an incentive in the industry to use animation to represent the dynamic and temporal features of new interaction and user experience designs through animation. While most of the existing examples are used primarily as viral marketing, we hypothesise that the potential is bigger than this. Building upon prior research on video sketching and video prototyping, this book asks whether the use of animation might also be viable in the earlier conceptual phases of the design process. In other words, *can animation actually be appropriated to become a sketching approach in design?*

THE STRUCTURE OF THE BOOK

This book is divided into three parts. *Part one* begins by defining the foundational concepts needed to understand the animation-based sketching of interactive digital systems. We review the state of the art in design sketching, in studies of emerging technologies, and in the field of animation, as well as their potential fit with design sketching. Thus, the first part of the book is focused on theory review, and is thus academic in its area of concern.

In *part two* we continue the theoretical track, but now with an emphasis on building theory. Here, we define animation-based sketching as a broad tool-agnostic approach that uses animation to portray fictional realities - but with the aim of realising them as facts. We use this definition to distinguish animation-based sketching from other branches of animation studies, such as the functional use of animation outside the field of entertainment and art. We suggest that animation-based sketching enables the designer to represent a digital system that does not yet exist and to generate temporal information about non-idiomatic aspects of the interaction design and user experience of the technology.

The *third part* then turns to the practical side of animation-based sketching. This section draws on examples from praxis and small constructed experiments designed to showcase specifics techniques as well as the design knowledge we might extract from using animation in design sketching.

Finally, we seek to assess the role of animation-based sketching as a tool that can inform decisions early on in the design process before more costly resources have to be devoted to development or implementation.

ANIMATION - A FUZZY FIELD OF STUDY

The study of animation is a broad domain, with much ambiguity (Ward 2003). Much of the ambiguity derives from the common insistence on a direct parallel between 'animation' and 'animated film' (Wells 1998, Furniss 1998, Wells 2002, Israel 2007). This is not strange, and, as Furniss (1998) argues, it is probably safe to say that most people think of animation in this way, in terms of a variety of techniques such as cel animation, clay animation, and stop-motion because they have seen the production techniques used in animated films. While much can be gained by analysing animation in light of of a film industry which evolved in tandem with modern animation praxis, the definition of the nature of animation is unnecessarily complicated by the indirect inclusion of animated film.

This is also why we do not refer to *'animated sketches'* but to *'animation-based sketches*': we see animation as an approach which can be used in tandem with other expressive tools to convey ideas, and not as a specific genre or medium per se.

The most difficult task facing animation studies is to map the perceived relationship between animation and cognate areas of knowledge and the ways in which practitioners in any of these fields respond to this relationship. Thus, addressing how knowledge increases, develops, and 'fits together' within the research domain of animation is arguably the first step towards describing the convergence between animation and design sketching. Animation scholar Paul Ward argues for the positioning of animation as a 'conjunctional' discipline (Ward 2003). The relationship of animation with fields such as film, media, and art & design makes it what it is. Ward pinpoints the importance of stressing the distinctiveness of animation as an object of study; it is actually not a completely coherent field or discipline, but a multi-sited field. It is a diffuse but epistemologically important set of ideas, theories, and methods. Ward proposes a conceptual map that allows us to contemplate where animation lies in relation to the cognate subject areas that have studied animation (figure 2)

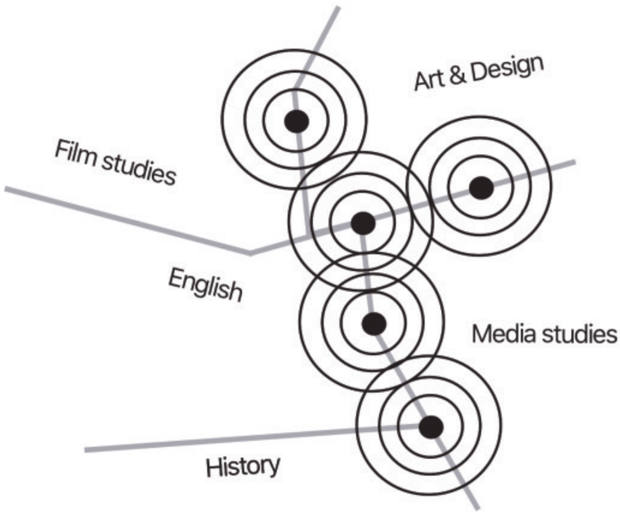


Figure 2: Paul Ward's ontological mapping of the multiple sites of studies onto animation, with rippling overlaps and fault lines between the different domains of knowledge.

The model depicts Ward's mapping of lines as the borders between different disciplines and multiple sites of animation-related inquiries. This creates ripple effects and fault lines overlapping other fields of study. Ward's ontological mapping serves to show the complexity of addressing the fundamental question of 'what it is'. For example, the close historical relationship of animation with the development of live action film has tended to mean that the theoretical and historical assumptions of cinema are either simply taken on board as if application to animation were unproblematic, or these assumptions are rejected out of hand solely because they originate from live action film.

Our goal of establishing animation-based sketching as a distinctive approach also adds a new site to this ontological mapping. Accordingly, the first step in this book is to establishment of the foundations for such an ontological mapping of animation-based sketching as a distinctive approach to using animation for design sketching.

PART I: THE FOUNDATIONS

Before embarking on the definition of animation-based sketching, we must first address the theoretical foundations of the various concepts that merge in this book. It is tempting to jump straight into the description of animation-based sketching in action and to present findings from various examples and experiments. However, building theory and method requires an understanding of the preconditions for the claim that animation-based sketching is a feasible technique for exploring new technologies. In the words of the pragmatic philosopher John Dewey:

> *"It is quite possible to enjoy flowers in their coloured form and delicate fragrance without knowing anything about plants theoretically. But if one sets out to understand the flowering of plants, he is committed to finding out something about the interactions of soil, air, water and sunlight that condition growth of plants."*
>
> Dewey, 2005

Consequently, this section undertakes a journey that starts with the fundamentals of design sketching and their function in the design process. A review of the limitations of traditional static sketching and the identification of a series of unexplored questions in the domain of temporal sketching lead us to propose the combination of sketching and animation. By analysing and categorising the relationship between these seemingly disparate fields, we seek to establish a foundation for providing a clearer distinctive definition of *the nature of animation-based sketching.*

CHAPTER 1
WHAT IS SKETCHING?

If the ambition is to describe animation-based sketching as a specific approach to design, we need to address 'design sketching' as an isolated concept before combining it with the concept of animation. This chapter examines the argument for a view of design sketching as one of the principal activities of design thinking, and it argues that we should view sketching as more than traditional pen and paper sketching.

We see sketching in terms of an intertwined relationship between the traditions of visual thinking and of visual communication. This relationship is not fixed: during the design process, it can change between the investigative, explorative, explanatory and persuasive functions of sketching.

Finally, we propose a new way of distinguishing between the concepts of sketching and prototyping on the basis of information theory. Sketching is the generation of new information, reducing uncertainty but increasing complexity. Prototyping then reduces complexity by testing the information generated through sketching.

DESIGNERLY WAYS OF FINDING OUT ABOUT THE WORLD

In discussing the study of design, legendary design philosopher Nigel Cross famously stated that *"there are things to know, ways of knowing them, and ways of finding out about them that are specific to the area of design"* (Cross 2006). Cross was one of the first to frame *design thinking* as its own epistemology. This was supported by Herbert Simon's proposal for fixating design in the artificial 'built environment' (Simon 1996). Richard Buchanan later adapted the concept of 'wicked problems' as specific characteristic for the type of problems designers face (Buchanan 1992). He proposed that designers approach ill-defined, contradictory, and constantly changing problems by respecting how the subject matter of design does not exist before being framed by the designer. The performative nature of this epistemology shows us that design bears an 'ontological politic' concerning what is being made (Gaver 2012), and that this amounts to a responsibility for creating possible future states of the world.

With the contributions of Cross and Buchanan and of a growing community of scholars, design thinking is now a recognised field with its own discourse of creative and solution-focused ways of exploring what Simon called 'preferred future states' (Simon 1996). Kolko (2010) emphasises abductive reasoning as how designers a balance the dialectics of problem setting and problem solving. Kolko relates abduction *sensemaking* as a natural human process, in which experiences are integrated into a more and more articulated understanding of the world (Klein et al's 2006). Via abductive sensemaking the designers add seemingly disparate information to the parameters of a problem setting. This changes the conditions, and through this kind af 'experimentation', the designer qualifies how a proposed *'might be'* a viable and desireable solution. Unlike the logics of either deduction or induction, abduction does not look for logic inherent in the premises, but allows for creatively hypothesise new meanings through qualified guesses. These guesses, or hypothesis' are not necessarily included in the original premises but added through using the designers experiences with familiar situations, and by experimentation via trail and error.

As an epistemological part of design thinking, abduction represents the designer's sensemaking process as an approach to asking *'what if?'* questions. Kolko describes the experiential conditions behind these questions as the unique signs the designers leave in everything designed - the evidence of how the abductively added their own lived experiences into the sensemaking behind the design (Kolko 2010). To enable abductive sensemaking in design mostly requires some kind of interaction with conditions of the problem - expressing a 'what if' question, which adds new information to the existing conditions of the problem setting.

This exploration of a framed part of the world is related to Cross's claim that designers have a 'specific way of finding out about' phenomena by generating knowledge through externalisations. This is essentially why Löwgren & Stolterman (2004) argue that the main output of the thoughtful design process is not the artifact but the *knowledge construct*. Design knowledge is primarily intended for other members of the knowledge construction culture of design, including not only designers, but also critics, stakeholders, and users. They can then share, debate, challenge, extend, reject, and reflect upon this knowledge, but this requires articulation in forms that can be appropriated and assessed (Löwgren & Stolterman 2004).

Externalising an idea makes 'visible' what was previously only a thought and makes the idea accessible for both the designer and others to expand, criticise, and further develop. In other words, it is through their external representation that ideas become 'real' and move the design process forward in figuring the preferred state of the world. It is often difficult for a design team to share and develop an operative image, since the members tend to understand ideas in widely different ways. Potts and Catledge (1996) studied this in a large software project for almost a year, describing the creation of a shared vision and its evolution into a final specification where the end result was ambiguous and contradictory. Thus, in order to cope with the complexity of the design process, the designer needs to externalise his or hers design thinking through external representations.

Cross himself used the notion of 'a drawing' or 'sets of drawings' as his example of these external representations (Cross 2006), and he argued that the drawing was the end point of the design process, which would then transcend into engineering phases on the basis of the drawings. While it is clear that this division is based on his emphasis on the design practice of architects and industrial designers, Cross's notion of 'the drawing' is still the basis for the way in which the majority of design thinking discourses talk about external representations - as sketching.

SKETCHING AS THE PRINCIPAL DESIGN ACTIVITY

The term 'sketch' usually denotes a rough or unfinished drawing, and to sketch is to give a brief account or general outline of something (Goldschmidt 2003, Goel 1995). The wording of the English term originates from the Italian *schizzo*, which in turn is based on the classic Greek term *skhedios,* signifying *'done extempore - spoken or done without preparation'* .

Sketching is recognised as the archetypical activity in nearly all disciplines associated with design (Buxton, 2010, Jones 1992, Krippendorf 2005, Schön & Wiggins 1992). However, various groups of researchers have examined the role of sketching in design from different perspectives, and there is an ongoing debate between them. Two key questions have been the primary focus of these debates; *what constitutes sketching* and *what is the function of sketching?* The first question is wether sketching is a stage in the design process (e.g. Simon 1996) or if it is specific set of techniques used throughout the process - mostly represented by pen and paper sketching (e.g. Jones 1992). The second question relates to what Löwgren & Stolterman (2004) call 'the knowledge construct' of design. In this approach, design is not seen as primarily concerned with making artifacts but with the construction of knowledge, which forms the basis for all designed artifacts. Sketching is considered the principal activity in this form of knowledge construct.

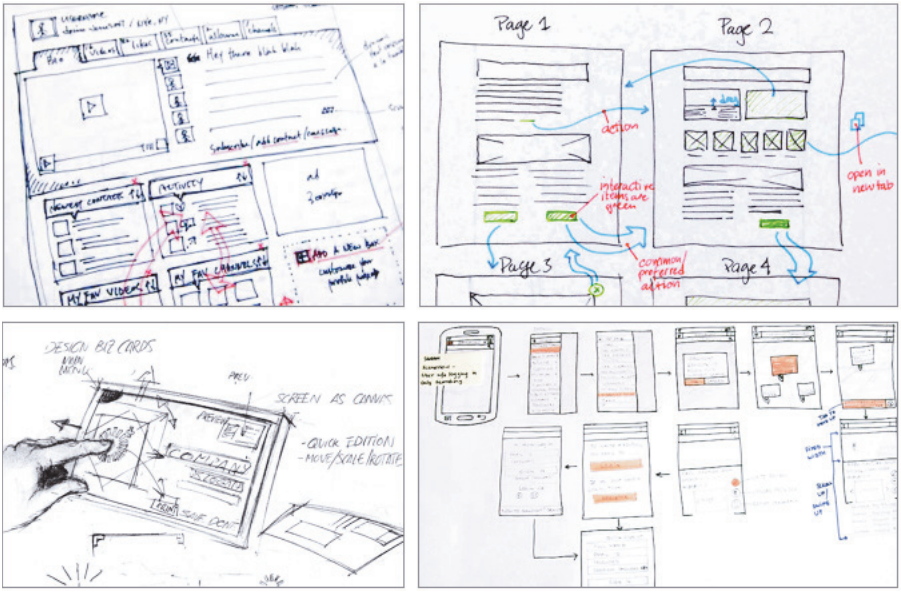


Figure 3: Design sketches are often a mess of fidelities, styles and concepts explored visually.

One dominant perspective on sketching sees it as the ability to mediate between the designer and the design problem in the sensemaking process. Here, sketching is primarily thought of as an approach for 'visual thinking' (Goldschmidt 1991 & 1993, Goel 1995, Arnheim 2004). The resulting research into how visual thinking enables the designer to 'have a conversation with the drawing' is quite extensive (Suwa et al 1998, Suwa & Tversky 1997, Verstijnen et al 1998, Bilda & Demirkan 2003, Schön 1983, Buxton 2010) and is broadly recognised as the primary value of sketching. This notion of sketching also answers the first question regarding 'what sketching is': it is a way of helping limited human mental processing to conduct a problem analysis in a reflective conversation with the design situation (Schön 1983). The designer sees what is 'there' in the representation of an idea, creates sketches in relation to it, and then examines what has been represented. This process informs further design moves.

A second perspective emphasizes the inclusive value of sketching in the design process. This perspective argues that the main value of sketching is its inclusive way of using visual spatial expressions in the design process (Lugt 2005, Schütze et al. 2003, Buxton 2010). The proponents of this view hold that since the design process is strongly influenced by feedback and critique from peers, the expressive function of sketching is of great importance; it allows a broad community of stakeholders to observe, comment on, and revise ideas through new reflections upon what is represented in the sketches (Frankenberger & Badke-Schaub 1998, Löwgren & Stolterman 2004). To the best of our knowledge, relatively few academic studies have focused on sketching as what we label 'visual communication'. The result is that sketching studies have developed a processual focus on 'sketching' and paid less attention to 'the sketch' as the outcome of this process.

AN INTERTWINED RELATIONSHIP

Questions regarding the nature of sketches and the value of sketching and sketches are not necessarily as clearly separate as the main theoretical contributions often lead us to believe. Nearly all of the most frequently cited sources actually do acknowledge that sketching is a specific integral step in the design process, that sketching is a specific set of techniques, and, even more importantly, that sketching has value both as an internal and external mode of exploring designs. The main difference is in their emphasis; researchers interested in the reflective practice of design (Suwa & Tversky 1997, Schön & Wiggins 1992, Goel 1995, Goldschmidt 1991) are primarily interested in the design process. Other sketching contributions such as those of Buxton (2010), Löwgren & Stolterman (2004), Lugt (2005) and Hutchins (1995) also show an interest in the design process, but they also prioritise the role of sketches as external communication and as a way of "*...putting the ideas out there*" for debate, critique, and new interpretations (Hutchins 1995). Thus, from a visual thinking and visual communication perspective, the function of sketching seems to encompass two aspects: it aids the construction of knowledge in the design process by generating new and more sophisticated information, and it allows assessment of the sketch.

Eugene Ferguson (1994) identified this intertwined relationship when he proposed a distinction between three types of sketch: *the thinking sketch*, *the talking sketch*, and the *prescriptive sketch*. The thinking sketch refers to the classic notion of visual thinking, where sketching is used to "...focus and guide thinking". Talking sketches, on the other hand, create shared points of reference in external visual communication to facilitate peer-feedback. Finally, the prescriptive sketch is a more formal rendering of the talking sketch that the designer can use to increase effectiveness in conveying the idea of a design to stakeholders who are disconnected from the design process. Ferguson's categorisation is a very concrete way to differentiate between the different values sketching can have, though it also implies that we have to determine which of the three types a sketch actually is. Even though the three types encompass both visual thinking and visual communication, Ferguson's categorisation assumes that the specific sketch has a rather finite nature. This leads to the obvious question of whether the designer needs to reflect upon the purpose of the sketch prior to the sketching process, or whether the category of the sketch is first determined after its creation. When sketching is seen in Schön's terms as a *'reflective conversation with the material',* it certainly creates a paradox if the classification of a sketch is to be established prior to the generation of the sketch.

THE MULTIPLE FUNCTIONS OF SKETCHES

One way of coping with this paradox is to regard the intertwined relationship between visual thinking and the visual communication of sketches as a dynamic relationship which may change over the course of time. This was the case in an earlier analysis of the functions of sketching (Vistisen 2015). Here the point of departure was Olofsson & Sjöflen's work (2007) and their indexation of sketches, elaborating Ferguson's work into four genres of sketching: *investigative*, *explorative*, *explanatory* and *persuasive*. The *investigative* function of sketching is related to examination of the problem space during the early phase of unfolding a design problem, and it belongs to the visual thinking perspective on sketching. *Explorative* sketching is used to express design solutions for evaluation and when those solutions may not make much sense to others than the people directly involved in the design process. This function is located somewhere between visual thinking and visual communication.

The *explanatory* function, on the other hand, involves communicating a clear concept to stakeholders outside the design situation. These sketches describe and illustrate proposed concepts in a neutral and straightforward manner to invite feedback from users, clients and external experts. In this sense, they are like the talking sketch. Finally, the *persuasive* function uses sketches for rhetorical purposes, with less ambiguity and more details. The focus here is on ‘selling’ the proposed design concept to influential stakeholders, removing the focus from reflection and emphasising something more akin to marketing. This is a more radical concept than Ferguson’s prescriptive sketch.

In Olofsson and Sjöflen’s book, the four genres of sketching were little more than an indexation feature - a way to separate the chapters. The underlying assumptions and consequences of categorising sketches in this manner were not discussed. Combined with Ferguson’s deeper reflections on the topic of categorising sketches, we proposed a new model in which the four categories of sketches might constitute a continuum, rather than strictly separate categories. The model is a continuum between the investigative and explorative function on one axis and the explanatory and persuasive functions on the other.

Figure 4: The sketching matrix, composed by appropriating Olofsson & Sjölen’s (2006) four categories, into a continuum of functions sketching can take during the design process (authors own model).

We have added ‘high’, ‘medium’ and ‘low’ to the vertical axis to indicate that a sketch might be assessed as combining qualities from more than one sketching function, although some qualities might be more important than others at a specific time. In the new model, time becomes an important aspect in explaining the different roles of sketches. The model indicates that different sketching activities and techniques might be used in the same way but with different values, depending on the time and context of use. Thus, as an alternative to seeing the various types and functions of sketching as representing fixed qualities, the same sketch might be seen as taking on different qualities depending, for instance, on whether it is being used to reflect about a choice of different design alternatives or is being shown to an external stakeholder in a project (figure 5).

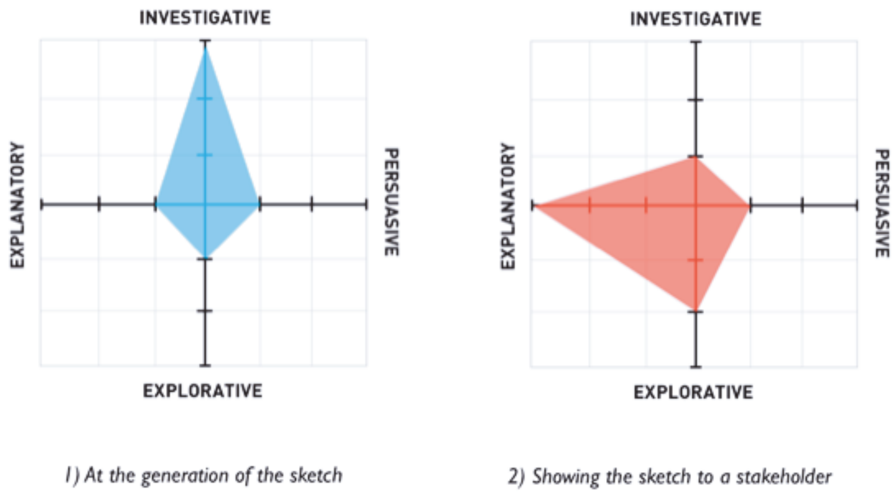


Figure 5: Two setups in the sketching matrix, depicting how the same sketch takes on different functions over the course of time in the design process (authors own model).

This takes the intertwined relationship between visual thinking and visual communication to its logical conclusion - sketching is both visual thinking and visual communication, and its primary quality is entirely dependent on when the sketch is used and for what kind of knowledge construct. Consequently, we do not assess the function of a sketch epistemologically in terms of its inherent qualities but in terms of the specific constellation of context and time of use.

LESSON LEARNED

In design, sketching is concerned with visual thinking and the output sketch with visual communication. These two exist in an intertwined relationship which changes functions over the course of time in the design process.

We might argue that even when no external audience is present, all sketching involves communicative intent and thus always involves the persuasive function to some extent. The sketch is framed, and this selects what is included and what is excluded. Even when using sketching to investigate the problem as a means of visual thinking, designers cannot avoid a measure of self-persuasion; they sketch certain aspects because of personal taste, domain expertise or external demands. In fact, this is true for all kinds of expressive capacity: they all involve leaving something in and leaving something out. Before the finished product has been realised, everything else is a matter of contingent selection. Thus, design is never objective. Instead, it involves a balance between showing the potential and elegance of a proposed future vision and leaving out enough details out for it to avoid being regarded as finite.

The new challenge for sketching is to assess how different approaches work in the continuum between investigation and exploration, between explanation and persuasion, and in the possible combinations between the four of them. This can lead to a revision of 'what a sketch actually can be'. Does a sketch necessarily resemble Cross's notion of 'drawing', or might sketching involve other materials and techniques?

I have discussed this issue in detail in an earlier publication (Vistisen 2014), where I described sketching in terms of Bill Buxton's seminal work on the role of sketching within the domain of human-computer interaction and user experience design (Buxton 2010). Buxton broadened the scope of sketching by suggesting eight criteria for determining when something is a sketch: *evocative, suggestive, explorative, questioning, proposing, provoking, tentative* and *non-committal*. Drawing on Buxton's criteria, we proposed that sketching should be seen as a specific mindset rather than as a definite set of constrained techniques. Sketching enables the abductive sensemaking central to design; in sketching, we do not explore *what is*, but instead seek to speculate about the conditions for *what might be*, then pruning and experimenting with them.

Buxton's criteria also mean that sketching should be regarded as way of acting upon the world in a more broad scope. We suggested framing these different expressive sketching capacities through a categorisation based on both the material context and the technological praxis enabling the sketching. Inspiration was drawn from the domain of interaction design, by using Gillian Smith's description of interaction according to its 'dimensions': 1-D, 2-D, 3-D and 4D (Smith in Moggridge 2006). Smith's categorisation was directed as a means of deconstruction the part of interactive products. However, we found the categories suitable for a broader use of the dimensions in which we practice design sketching. Consequently, I proposed a typology for the mindset of sketching applied in both 1-dimensional sketching (e.g. thought experiments), 2-dimensional sketching (e.g. pen & paper sketches), 3-dimensional sketching (e.g. models and mock-ups) and 4-dimensional temporal sketches (e.g. enactments, video and animation).

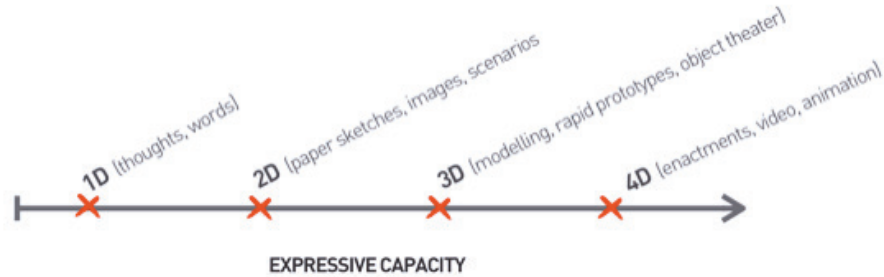


Figure 6: Scale of expressive capacities in sketching, from 1-dimensional thoughts and words to 4-dimensional temporal capacities like video and animation (authors own model).

This typology of the expressive dimensions in which the sketching mindset can be applied involves the hypothesis that expressive capacity increases when further dimensions are added to sketching capacities. For instance, when sketching with materials and techniques that accommodate temporal aspects, we are able to generate richer design knowledge about things that unfold over time than we would if the sketch was produced through pen & paper. Whether this richer temporal design knowledge is necessary to move the design process forward is highly dependent on the design problem and its subject matter. We limit this notion of higher expressive capacity to the domains of interaction design and user experience design, which, to a higher degree than most other design domains, have the dynamics of time as their subject matter (Kolko 2011). In this regard, the typology in general does not specify which sketching capacity is preferable, instead proposing that designers have a broad range of expressive capacities from which they can choose from when they are exploring a design problem.

SKETCHES VS. PROTOTYPES - PRINCIPLES, FEATURES OR DEFINITION?

A review of past academic publications and contributions based on design practitioners' reflection-on-action reveals how the term 'sketch' is often used either as a synonym for so-called 'prototypes' or as a 'low-fi' reference to prototypes (Snyder 2003, Svanaes & Seland 2004, Rudd et al 1996).

This confusion is unfortunate since it raises an obvious ontological question: if the two terms are interchangeable, why do both terms exist? Some would argue that the confusion arises from differences between the fields of origin: sketching originated in the design discourse of architecture and industrial design (Schön 1992), and prototypes originated in the computer sciences and engineering (Ferguson 1994). However, the history of the two terms still does not clarify 'what they are' and 'how they differ'. Some scholars have illustrated the difference indirectly by proposing various principles and techniques for creating different types of design sketches (Ferguson 1994, Olofsson & Sjölen 2007, Buxton 2010), and other principles and techniques for variations of prototypes (Wirklund et al 1992, Sears & Jacko 2009, Hill & Houde in Helander et al 1997). While such principles are helpful when it comes to applying a specific technique, they still lack the formality of a definition and may be criticised for still being interchangeable.

In his seminal writings about using a multitude of media as sketching capacities in user experience design (Buxton 2010), HCI scholar Bill Buxton moved a step beyond principles of sketching and prototypes. Rather than setting up specific principles, Buxton attempted to create a set of characteristics defining what constitutes a sketch and a prototype (figure 7).

Sketches are...	Prototypes are...
evocative	didactic
suggestive	descriptive
explorative	refining
questioning	answering
proposal	testing
provoking	resolving
tentative	specific
non-committal	depictive

Figure 7: Buxton's (2010) characterisation of the difference between between sketches and prototypes.

Buxton's list of defining characteristics constitutes a point of reference that is arguably stronger than most other attempts at clearly articulating the difference between sketching and prototyping. He also approximates a definition in his notion that sketching in design is concerned with *'getting the right design'* and that prototyping within usability engineering is concerned with *'getting the design right'* (Buxton 2010). In other words, we might say that sketching asks *'what is the problem and how might we solve it?',* whereas prototyping asks *'which solutions are most feasible?'* This distinction works well in discussion of the *aim* of sketching and prototypes, but it hardly addresses the formal difference regarding *what* they are. While they are defining, such characteristics are hardly precise, and since they seem to exist in a continuum, Buxton also acknowledges that the characteristics sometimes seem to overlap when one is attempting to determine whether a given material, process or technique is more suitable for sketching or for prototyping on the basis of his framework:

> *"The real value in drawing a marked distinction between sketching and prototyping lies not in the end points, but in recognising that there is a continuum between them. An awareness of it, its properties, and its implications, may help guide us in how and when we use different tools and techniques.*
>
> *[...] how a technique is used is the ultimate determinant of whether one is sketching or prototyping."*
>
> Buxton 2010, 248

The last part is especially important, since Buxton acknowledge that what specifies the label of a given technique in his continuum of characteristics is not defined by anything inherent in the technique itself, but by what it is used for. This begs the question of whether it is possible to formalise what sketching and prototyping are used for and thus create a more formal definition of the two terms.

Uncertainty vs. complexity

In Vistisen & Rosenstand (2016), we suggested that we should draw on the domain of information theory to create a more general formal definition of the division between sketching and prototyping. On the basis of Herbert Simon's theory of bounded rationality (Simon 1973) and of the development of ways to describe bounded rationality in regard to the information society (Newell & Simon 1972, Mathiassen & Stage 1990), we argue that sketching and prototyping can be differentiated in terms of how they deal with uncertainty or complexity. Uncertainty is a negative measure of available information – the lack of information. This is opposed to complexity, which is a positive measure of available information, or information at hand. On this basis, sketches and prototypes can be differentiated in terms of the information they add to the design process. We position sketching as the explorative generation of new information. Sketching adds knowledge by filling out gaps in the information about which possible design alternatives might be viable, desirable, and feasible, and thus it reduces uncertainty. This fits Buxton's characteristics of sketches as 'proposing' and 'explorative' while emphasising 'what sketches do'. While generating information, however, sketching thus also increases the complexity of the design situation, and the designers now have to choose between and evaluate a series of alternatives as the best fit for further development. In this regard, prototyping is a process which reduces complexity by putting the most promising information to the test. This aligns with Buxton's characteristics of prototypes as 'testing' and 'refining'.

We argue that this information-based distinction makes description of the fundamental qualities of sketching and prototyping both easier and more precise, and it clearly articulates the difference between the two activities. The definitions supports an understanding of typical design process models (e.g. Boehm 2000, ISO 9241-210:2010), in which sketching is typically dominant in the front-end phase due to the lack information at the beginning of the project - an uncertain situation. This uncertainty creates the need to use a fitting technique to sketch design alternatives that can inform further decisions. Once design alternatives have been created, we now have more information than needed in the form of multiple design concepts. This creates the need to choose between the different alternatives. In other words, complexity has to be reduced through prototyping.

LESSON LEARNED

Sketching is concerned with the reduction of uncertainty by generating information

Prototyping is concerned with the reduction of complexity by testing information

In relation to the previous division of sketching mediums into 1D-4D capacities, the distinction between uncertainty and complexity further illustrates how the same medium might be used for both sketching and prototyping. When the aim is to reduce uncertainty about what is to be produced, the action is sketching, and when the aim is to reduce the complexity surrounding the question of which of the possible ways to realise the design is the most viable, the action is prototyping.

A GENERAL SKETCHING MINDSET TO BUILD UPON

This way of approaching sketching as a specific mindset that is applicable in a multitude of dimension means that a range of materials may now be considered applicable for sketching. These materials provide an increase in expressive capacity that can overcome some of the natural limitations of the traditional ‘drawing’ genre of sketching with pen and paper. In the next chapter, we will review these limitations in relation to the challenges of exploring early design ideas regarding non-idiomatic technologies.

CHAPTER 2
THE LIMITATION OF DESIGN SKETCHING

While design sketching can be identified as one of the principal activities of design thinking, and while the process itself is a crucial reflective part of gaining design knowledge, sketching is sometimes inadequate to express dynamic and interactive aspects of a proposed design. This is especially true when the proposed design involves aspects which lack established conventions or best practices.

This chapter examines the limitations of sketching in its traditional static sense. We analyse these limitations to provide a better framing of the concept of new emerging technologies, which we describe as 'non-idiomatic'.

THE IDIOMATIC STRUCTURE OF STATIC SKETCHES

As we have discussed, sketches has the capacity to represent and externalise ideas; that is, sketches make internal thoughts public. Sketches do this in another way than e.g. written language, by making it possible to convey visuospatial concepts directly, using a language of visual forms (Tversky 2002). This makes sketches public, and thus allows for other than the individual design thinker to observe, critique and propose revisions on the idea - maybe even enacting new sketches in the process. Together with the reflective practice of the sketching process itself, this externalisation enables the reflective practice of sketching.

Sketching as visual vocabularies

When sketching in traditional static pen and pencil, the designer usually starts with a blank canvas which is potentially open for the expression of any kind of concept. However, existing studies have shown that when designers sketch, their sketching can be categorised into segmented elements (Tversky 2002), composed by shapes, figures, signs, and diagrams (Zacks et al 2000). Goodman has noted that these segments even have language like properties, combining in different ways to produce different meanings and thus constituting the syntax of the semantics of the concepts (Goodman 1968). Tversky's study shows the extent to which semantics can map onto the meaning of linguistic elements, for instance idioms for certain expressions and annotations (Tversky 2002, 4). Drawing on a survey of sketches produced across ages and cultures, Tversky demonstrates how sketches can include depiction not found in realty, but rather annotates reality - such as boundary lines, arrows and exclamation marks.

As such, sketches consist of a repertoire of stylised elements which can be combined, mixed and matched. As an example, architectural sketches can be deconstructed into a rather small set of elements, which combined can create the most creative and vivid structures (Do and Gross, 1997). Even outside the design domain, children throughout the world draw human heads and bodies as circular blobs and add sticks for arms and legs (Kellogg, 1970).

This corresponds to what Löwgren labels *visual formalisms* (Löwgren 1996), a term which refers to elements in which their relations and semantics are established by convetion. Nardi and Zarmer (1993) suggest that they are based on simple visual objects such as maps, tables, graphs, plots and panels. Greenberg et al (2012) apply this to sketching, summarising a number of common visual formalism to create a 'visual vocabulary' of the sketching language.

Figure 8: A small cut of the visual vocabularies of sketching, as presented by Greenberg et al (2012), showing of idiomatic patterns of objects, and actions.

In essence, visual vocabulary and visual formalism are a set of learnable idiomatic elements which speak in a strong simplified voice. Sketching vocabularies and their semantic combinations cannot convey the exact configuration of the world, but they suffice to create the reflective conversation with the material needed to explore the design problem. In fact, the way in which sketches distort the configuration of the world might even be one of the drivers of abductive sensemaking (Kolko 2009); they loosen the framing of extant reality to allow exploration of a preferred state of affairs. Thus the vital characteristic of design sketching is its ability to leave 'gaps' in its expression that are big enough to facilitate reflection while still using known idioms and patterns to create broad recognition.

Pattern languages of design

The whole notion of a visual vocabulary in design owes a lot to early work on visual formalisms by Christopher Alexander (1964). Alexander recognised the combinatoric nature of architectural designs and analysed the relationships between different applications and combinations as well as the idiomatic relations between architectural designs; the resulting reusable segments were what he labeled '*pattern languages*'.

A pattern is an abstract collection of relationships within a small system of interacting and connecting elements and is independent of all other elements. The idea is that it is possible to create such abstract relationships one at a time and fuse the resulting relationships into whole designs (Alexander 1964). Because the patterns are independent of one another, we can study them and manipulate them one at a time so that their evolution can be gradual and cumulative. Moreover, because patterns are abstract and independent, they can be used to create an infinite variety of designs, all of which are combinations of the same set of patterns in the evolving language. The language metaphor creates the basis for seeing design patterns as *networks of truths* (Alexander et al 1977, 18) and as endless sequences of semantic combinations. The sequence of patterns is both a summary of the language and an index of the patterns. Thus, if the combinations were read together, an overview of the pattern language would emerge. This is how Alexander's concept of patterns helped to form what designers now label 'best practices' (Bogan 1994), which constitute a way of connecting the multiple sequences of semantic patterns within a specific design domain to reveal the current state of its pattern language as the current state of the art.

Later on, object-oriented computer scientists began to adopt the pattern language concept (e.g. Gamma et al 1994). Like Alexander et al's (1977) pattern language, design patterns of software described reusable insights about software design, which was concrete enough to be used, but still abstract enough to be applied and mixed in situations.

HCI researchers such as Jenifer Tidwell (2005) have used the pattern approach to systemise reusable forms and styles for combination in the user interface of digital products and to solve re-occurring usability problems. These design patterns document different models of interface actions and interaction behaviour, which are proven useful in enabling a given systems user to complete their tasks.

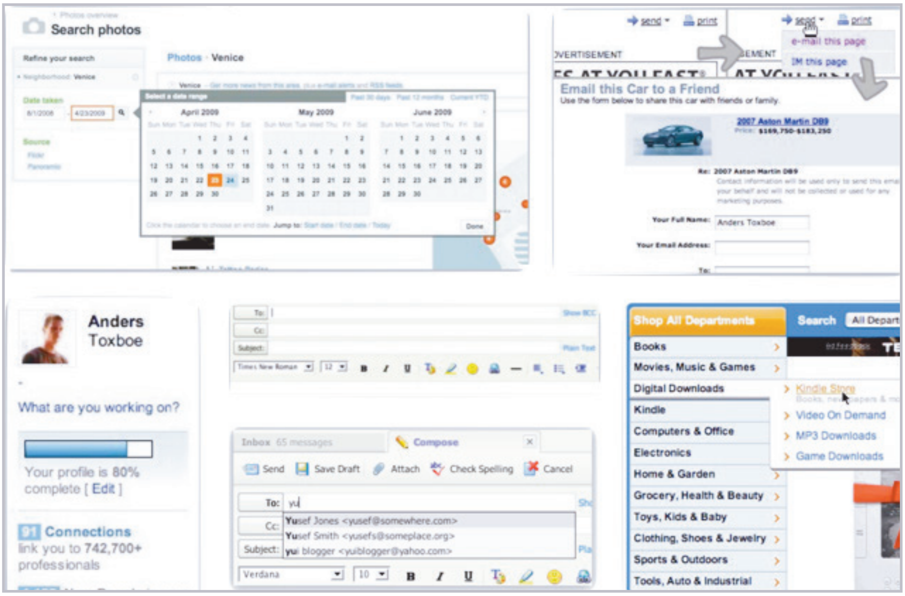


Figure 9: Multiple instances of design patterns for digital user interfaces, solving recurring problems of interaction and user experience design.

When designers are working on a digital product presented through rather standardised design patterns, traditional representation techniques work well (Greenberg et al 2012). Examples include pen & paper sketches, storyboards and multimodal combinations When designing a web-site, the designer often knows the context of use and the requirements of the web-site, and she may investigate the business and user goals of similar sites or services. The designer can draw on years of knowledge acquired from the web-design domain to experiment with established design patterns, combining them in new variations. Likewise, when sketching the initial ideas, the designer can use an array of established idioms from the domain to express ideas and can leave out details, relying on the ability of the community to fill in the gaps. We design against the backdrop of the collective experience and practices of our specific design domains. When a design problem has a known context, a known problem and familiar patterns and idioms for possible solutions, we label it a *normative design problem*. Normative design problems draw on idiomatic interactions, enabling the designer to fill in the blanks of how an interaction would take shape - even in a static medium such as a sketch.

LESSON LEARNED

Design idioms replace the need of certain expressive capacities in a design sketch due to the experiential knowledge filled in by the designer.

However, complications occur when the design depends on highly interactive and complex behaviour that is costly or difficult to represent using conventional techniques (Arvola & Artman 2006). In such design settings, the static patterns of sketching can only take the designer so far in the attempt to describe the multiple states of the dynamic system. In such cases, static sketching may never really generate all the information needed to explore the idea fully. Furthermore, with the emergence of new digital technologies and their integration into more and more aspects of society, the classical segmented elements of design idioms and design patterns fall short in terms of expressiveness. The designer must now sketch outside the established idioms of known conventions and practices.

NON-IDIOMATIC TECHNOLOGY - SKETCHING OUTSIDE 'THE KNOWN'

We argue that one of the domains that lack established design patterns or conventions is the emerging landscape of dynamic digital devices. Such devices offer features such as multi touch screens, accelerometers, gyros, compasses, barometers, and cameras, all of which are embedded in a rapidly changing eco system of services, platforms and devices. Warwick's work (1997) indicates that areas such as artificial intelligence, robotics, virtual reality and persuasive computing all belong to the umbrella concept of 'emerging technologies'. Emerging technologies can be understood in terms of their technical nature, but their impact on socio-economic structure is just as important:

> *"radically novel and relatively fast growing technology characterised by a certain degree of coherence persisting over time and with the potential to exert a considerable impact on the socio-economic domain(s) which is observed in terms of the composition of actors, institutions and patterns of interactions among those, along with the associated knowledge production processes. Its most prominent impact, however, lies in the future and so in the emergence phase is still somewhat uncertain and ambiguous"*
>
> Rotolo et al 2015, 1827

This description portrays emerging technologies as a growth factor, which indicates how far the technology has moved from invention and refinement to reach the tipping point of actually gaining public traction. Bill Buxton labels this ‘the long nose of innovation’ (Buxton 2008). Furthermore, the definition offered by Rotolo et al emphasises an interesting relation between the potential impact of emerging technologies, and the ongoing ambiguity and uncertainty about their actual innovative potential - it is due to a lack of information about what is viable, feasible and desirable.

This mixture of promise and uncertainty makes it more challenging than ever for designers to rely on the known idioms of design patterns when they are exploring and assessing potential use cases in emerging technology. What is lacking is the visual vocabulary - the well-defined semantics for expressing relations (Nardi and Zarmer 1993). Such formalisms draw on simple visual objects such as maps, tables, graphs, plots and panels, and they contain their own semantics instead of metaphorically recreating the semantics of some other domain. A number of research contributions have shown that this lack of design patterns makes it difficult to sketch using the idioms and best practices usually applied in design - the conventions that are *learnt*, not analogically or metaphorically transferred (Cooper et al 2012). Consequently, these emerging technologies might be characterised as ‘non-idiomatic’ (Lindel 2012, Löwgren 1996, Lowgren & Stolterman 2004).

Löwgren (2004) explains that the dynamics of interactive systems means that most non-idiomatic technologies are hard to grasp in static expressions and that this constitutes a challenge:

> *“We are increasingly facing design situations where the intended use takes place on the move, using various mobile and embedded technologies”*
>
> Löwgren, 2004

Non-idiomatic technologies merge into and transform the foundation of our way of being in the world; they change more and more aspects of our reality. Joseph Pine & Kim Korn have framed this in their concept of the ‘*multiverse*’ (Pine & Korn 2011), which encompasses the multiplicity of when experiences happen *Time↔No-Time,* where they occur *Space↔No-Space*, and what they act on *Matter↔No-Matter* (figure 10).

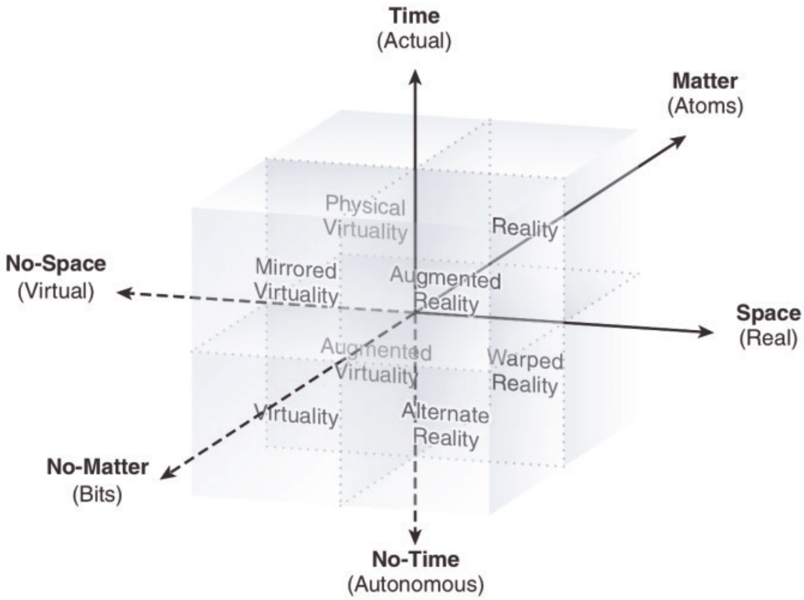


Figure 10: Pine & Korn's (2011) model of the multiverse, depicting eight quadrants of technological genres - some with a broad range of established idioms and conventions, while others have significantly fewer.

The model and the underlying analysis are of popular scientific origin, but what is inspiring is the overall metaphor and, in particular, the way in which it categorises the multitude of digital technologies. In the eight quadrants of the multiverse, a framework of technological genres emerges. This framework describes the multitude of ways in which digital technologies can merge into and affect both the real world and the virtual world. Although nothing specific is stated about the idiomatic nature of each quadrant, the framework serves as an example of areas beyond the established digital design domains of websites, apps and games, and it provides an ontological simplification of *how* they differ. Furthermore, the model also indicates that more or less all the digital genres involve a highly dynamic relationship between space, matter and time. The non-idiomatic aspects of a technology arise from the lack of established conventions about such dynamics. The framework helps to clarify *which* information exists in terms of patterns, idioms, and best practices, and what does not exist in these familiar forms. These gaps in information challenge the designer who is exploring the potential use cases for a new technology. In turn, they also limit the extent to which the designer's toolbox can provide sufficient information. Until generally accepted idioms or design patterns are culturally established, the design process involving a new emerging technology will deal with what we label *non-idiomatic design problems*. This entails a process of great uncertainty in the front-end of the design process, which means that the initial setting will be 'fuzzy' (Reid et al 2004).

LESSON LEARNED

When the design situation handles technologies or interactions with few or no conventions the design situation becomes ***non-idiomatic,*** and design idioms often become insufficient.

The challenge of statically sketching non-idiomatic dynamics

When dealing with fuzzy non-idiomatic design situation, designers must rely on their experience from other technological idioms, using methods, tools and techniques which might at best be a 'force to fit'. This challenges the capacity of sketching to reduce uncertainty by creating new information, since the designer has few idioms to use when sketching in this non-idiomatic domain - or perhaps none at all. Furthermore, from pen & paper to more sophisticated mock ups and widget tools, the static nature of conventional sketching methods means that they lack the expressive capacity to generate temporal information about the dynamics of use situations where technologies are embedded in various devices, touch points and contexts, and where patterns of interaction are untraditional. The main issue in exploring the finer grain of interaction involves the experiential qualities of the interplay between user and product over time - the temporal information. Consider the range of expressive dimensions we touched upon in the last chapter (figure 11).

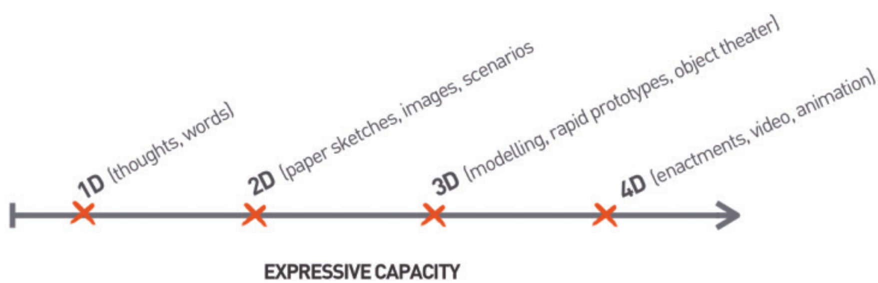


Figure 11: Every experiential capacity, such as space, time and interaction, requires equally higher expressive capacities of sketching dimensions.

Idioms replace the need for fine-grained temporal information about the dynamics of the system and make it viable to sketch in lower expressive dimensions. Whereas some things are established and conventional enough to be understood through words, other issues require visual thinking in pen and paper. This is a central reason why a designer can sense more feedback from a sketch than it makes explicit: it speaks to the idiomatic knowledge of the designer. The problem occurs when the temporal information needed is based on dynamics of which the designer has little idiomatic experiential knowledge – or none at all. The idiomatic point of reference is no longer available, and the designer can no longer foresee the consequences of the dynamic and temporal aspects of the possible uses of the technology. The situation becomes non-idiomatic.

From this perspective, we can frame the limits of traditional 'static sketching' in terms of its expressive capacity to explore the interaction design of technologies beyond established patterns, idioms and best practices. According to Cooper et al, "*...interaction design is first and foremost the design of behaviour that occurs over time*" (Cooper et al 2012). We might thus frame the challenge of traditional sketching as primarily a 'temporal limitation'. Buxton has noted this temporal limitation in a critique of the often-applied method of 'scenarios' (Carrol 2000) when it comes to exploring the interaction design of a new technological application (Buxton 2010).

Figure 12: Buxton 's (2010) example of multiple design sketches forming a design scenario of the scanning of a shop product with a phone app. The designer has attempted to capture temporal dynamics through the use of arrows and colour annotations.

Buxton points out that scenarios and other storyboard-oriented ways of portraying temporal information tell the designer a lot about individual 'states', but almost nothing about 'transitions'. They capture the static display of interfaces and product forms, for example, but the temporality of interactions themselves are only implied by the space between states or by crude annotations. From Buxton's perspective, the user experience of something is shaped more by what happens between each state than by the states themselves; it is important not to leave out too much temporal detail out for designers to fill in by themselves. When we lack known idioms to sketch from, it becomes harder to fill in the gaps regarding the temporal aspects of the interaction because experiential knowledge of the technology in a given context is inadequate. Accordingly, such sketching in interaction and user experience design is quite different from sketching in other design domains. Interaction and user experience design has focus on expressing the dynamics of interactivity, multimodality, tangible, haptic, audible and immersive experiences (Cooper et al 2012, Svanæs 2000, Fällman 2003). These are all characteristics that could also fit the notion of emergent non-idiomatic technologies.

Thus, non-idiomatic technologies are challenging due to the lack of temporal and dynamic information in traditional static sketching approaches. Approaches for exploring the experience and interaction design of such technologies must differ from conventional static sketching since they have to generate temporal information about the dynamics of both the system and the user experience to reduce the uncertainty of the design process. The issues involved in generating and facilitating reflections about the temporal and dynamic aspects of non-idiomatic design problems are the topics of the next chapter.

CHAPTER 3
TEMPORAL SKETCHING

This chapter presents a review of how non-idiomatic design projects have attempted to meet the need for temporal and dynamic information by using what we label *'temporal sketching approaches'*. We describe cases involving the application of video-sketching in non-idiomatic design cases, and we also include examples where animation is used to augment the video sketches but where the designers have scarcely reflected upon the animated aspect.

From this overview, we identify a range of preconceptions for the use of animation in sketching. Animation has previously been used in design visions, but with production qualities that exceed the possibilities offered by design sketching. Video can be employed throughout the design process, but without animation, the portrayal of interactive designs that do not yet exist is limited to props and enactments without formal design elements. Thus, we argue the need for further examination of whether animation is viable for sketching if aligned with the uncertainty reduction of sketching.

SKETCHING TEMPORAL AND DYNAMIC INFORMATION

We have established that design sketching is the generation of information to reduce uncertainty about design possibilities. Traditional static sketching approaches are challenged when they are used to explore the dynamics of interaction and user experience with new technology which has non-idiomatic aspects. Consequently, the need arises for the 4D sketching capacity introduced in Chapter 1 - what we term temporal sketching. In meeting the challenge of sketching non-idiomatic technologies, temporal sketching should specifically enable the generation of temporal information.

Video - the precursor for animation in design sketching

The 4-dimensional forms of expression have previously been explored as sketching mediums (Buxton 2010, MacKay & Fayard 1999, Mackay et al 2000, Bardram et al 2002, Zimmerman 2005, Vertelney 1989). In particular, experiments have been conducted using live-action video as a sketching medium, building on the suggesting that techniques of film are ideal for conveying temporal aspects such as timing, movement, and dynamic relations (Ylirisku & Buur 2007, Vertelney 1989, Bardram et al 2002). Passman (2012) points out that with its ability to capture the richness of life as it unfolds, video is a feasible medium to register the world *as it is now* and to visualise the world *as it could be*. Raijmakers (2009) notes the ability of the medium to showcase experiences through time and in context: *"Film is definitely the most powerful tool to an emotional understanding of the user"*. Empathy for the user is a central goal of any user-centered design process, and video can be perceived as an intermediate artefact during design and as a means of persuasion that can engage people in the design process (Veland & Andresen, 2007). Finally, video can be applied as a change agent, functioning *"...as persuasion to present complex ideas in a concentrated and exciting way for influencing research directions and decisions,"* (Chow 1989). In this connection, Ylirisky & Buur even noted how video scenarios in design could *"...in a way replace the need for functional prototypes that provide people with the overall experience of the system in fluid action"* (Ylirisky & Buur 2007, 33). Botin & Bolvig (2015) have added that video scenarios can present the emotional, social and cultural aspects of concepts before they are created. This is supported by Veland & Andresen's (2010) notes on the technical feasibility of video; recording hardware, editing software, and distribution platforms are now both cheap and easy to access.

These approaches are commonly labelled in terms of the common concepts of 'video prototypes' (Vertelney 1989, MacKay & Fayard 1999, Young & Greenlee 1992) or 'video sketches' (Zimmerman 2005, Bardram 2002, Tikkanen et al 2008). However, no real justification is offered for the use of the terms 'sketch' and 'prototype', other than the interchangeability that we identified earlier. Many of the contributions also seem to use live action video and animation as interchangeable parts of the 'video' label, leaving reflections upon the specificity of animation more or less out of their analysis.

Ylirisky & Buur's book 'Designing with Video' (Ylirisky & Buur 2007) is particularly noteworthy. It covers the broad potential for applying video in design processes, but, as we will argue, it also distorts the potential of animation by linking its role solely to that of augmenting live action video prototyping. Ylirisky & Buur argue that video plays a role either as the designer's 'clay', enabling the expression of concepts, or as 'social glue', where video supports the social process of collaboration and the development of an operative image of the design problem and possibilities. The authors provide an impressive review of techniques and processes for the application of video in design processes, and they also dedicate a section to exploring a topic aligned with what we have described as the sketching mindset: 'generating information which envisions the future'. Whether the aim is to improvise in an investigative manner, doing future ethnography from an explorative and communicative perspective, or to persuasively argue for a certain view of the future, Ylirisky & Buur argue that *"concrete images of possible futures enable the making of judgements about what would be preferable" (*Ylirisky & Buur 2007, 181*)*. For Ylirisky & Buur, video prototypes are illustrations of how reality could or would if what the temporal sequence proposes is resolved. They argue such sequences should 'provoke' as well as 'propose' in order to overcome status quo perceptions. Thus, video does not *tell* us about the future. Rather, it invites us to have a conversation about it, establishing a shared point of reference for communicating about the desirability, feasibility and viability of proposed design ideas.

Animation - an expensive high fidelity tool?

As well as discussing the creation of video prototypes to provoke change, Ylirisky & Buur also discuss the question, "What scale would be appropriate with the resources we have?" Their analysis examines the "Starfire" video prototype described by Bruce Tognazzini (1994) and the Apple Knowledge Navigator (Buxton 2010), which applies professional video, acting, animation and special effects to portray an idea of the future.

Figure 13: Still images from one of the vision videos, depicting the Apple Knowledge Navigator concept from 1987 - envisioning many of the uses of tablets, AI assistants and networked collaboration as we see partially in use now by 2016.

This process is described as similar to the creation of a live action movie, as outlined by film scholars (Rosenthal 2007, 12), and it involves *(1) script development, (2) pre-production, (3) filming, (4) editing, and (5) final lab work*. Ylirisky & Buur also briefly cover the use of animation, but mostly in the creation of 'special effects' in video prototypes. Here, animation to create motion graphical elements is practically synonymous with the notion of 'high fidelity special effects'. This is one of the critical elements of the use of animation that is covered by Bill Buxton's critique of the Apple Knowledge Navigator concept (Buxton 2010). The Knowledge Navigator was an environment video showcasing the potential of R&D technologies of the time, such as touch screens, hypermedia collaboration and artificial intelligence assistants, where all digital elements were animated to portray the device as 'real' in a range of short storylines. With reference to the budget, the production quality and the rhetorical aim of persuading people about the technological ambition, Buxton's main argument was that this use of animation was not a sketch; it was only a vision (basically intended as a sketch of the future), but it ran out of control and was perceived as a promise regarding how a specific product would be launched and would function. Removed from the context of the presentation of the video, the visual vocabulary and production values were too persuasive: people started to believe that Apple was actively working on the system (Buxton 2010, 365).

Buxton argues that even if The Knowledge Navigator had been quick, timely, inexpensive and disposable, it would still not have worked, since it involved telling a story about the future instead of asking whether this would be the preferred story. In terms of our matrix of sketching functions, Buxton's critique is that the Knowledge Navigator became almost purely persuasive; its explanatory and explorative purpose were overshadowed.

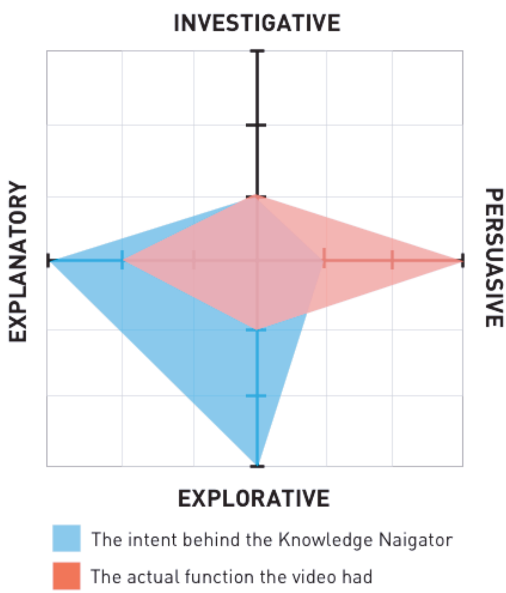


Figure 14: The sketching matrix, mapping how the Apple Knowledge Navigator vision videos took on a more persuasive function, than the intent described by its creators.

Buxton points out that this issue is a result of one of the main strengths of high fidelity renderings: they are the attractive results of craftsmanship, and are thus seductive. This relates back to Chapter 1 and our discussion of the omnipresence of a degree of persuasiveness in design sketches. In a sense, the higher the fidelity, the higher the persuasiveness of the sketch, and this entails an increased risk of the sketch not being perceived in the right way as something tentative and not finite.

Ylirisky & Buur elaborate on this issue in examining a design case from Nokia which envisions the future of context-aware mobile phones and pervasive computing environments, Substantial resources planning, filming and editing of the finished video scenario resulted in a high-fidelity rendering of their proposed design vision. Ylirisky & Buur note how the created video:

> *"...had an impact on numerous projects. It has been presented in various situations at Nokia and also at numerous seminars and conferences."*
>
> *[...]*
>
> *"With the cost required for realising virtual 3d-models and animations, it is clear that this is only appropriate for long-term visions at corporate level. For visualising short-term research ideas, e.g. of less than five years, one would need cheaper and faster production and to focus on the business benefits."*
>
> Yilirisky & Buur 2007, 215

Ylirisky & Buur conclude that without big budgets of the scale devoted to the future vision video at Nokia, few techniques are available for the small-scale representations of designs that explores the 'what if' of the not-so-distant future. Without animation and its ability to create apparent motion in graphic positions not fixed in reality, video as a sketching medium is limited to capturing the world of 'what is' and is only able to *illustrate* the world as it might be. Thus, in light of Ylirisky & Buur's critique of the cost and time required to use animation in video prototyping, the potential of animation for portraying patternless non-idiomatic technologies would seem limited.

Bill Buxton arrives at much the same conclusions as Ylirisky & Buur regarding the fidelity danger of being "...*sucked in by this fascinating craft, and in the process, losing sight of why you are using it. We are sketching interaction, not Toy Story*" (Buxton 2010, 299). Like Ylirisky & Buur, however, Buxton does not discard animation all together, but proposes the adaption of rough animation techniques, such as Terry Gilliam's cut-out techniques in 'Monty Python' and the stop-motion style of 'South Park'.

Figure 15: Still images from 'Monty Python and the Quest for the Holy Grail' and 'South Park: Bigger Longer, Uncut' - both examples of simplistic and cruder animation fidelities than that of Disney studios.

In the end, Buxton does not present a clear proposal for a sketching approach for animation but acknowledges that early on in the design design process, the focus is typically to explore different alternative proposals, rather than refining one single design in program code. Following this, as long as animation can be appropriated to be cheaper and faster to get feedback from, than implementation in code, it is potentially a valuable tool in design.

Approaches for improvising artifacts and services include the use of props (Brandt et al 2012) or the body (Oulasvitra et al 2003, Arvola & Artman 2006). For instance, Binder's (1999) improvised scenarios were shot in context with a consumer grade camera and props in cardboard and foam. Mackay et al (2000) deployed a technique called "video brainstorming", which lets designers present proposals in a more vivid and memorable way writing design briefs. However, without the layer of artificially created motion and effects provided by animation, the ability to explore emergent non-technologies is somewhat limited due to the limited simulative ability of the video medium per se. This also constitutes a limitation of its sketching capacities.

LESSON LEARNED

Video can be utilised throughout the design process - but without animation, the portrayal of not yet existing interactive designs are limited to props and enactments without formal design elements.

Animation has previously been used in design visions - but with production qualities beyond what is viable in design sketching.

These insights present us with two interesting unanswered questions: ***Is animation at all suitable for use outside big budget future visions?*** Further, if it is suitable, ***how can we appropriate animation to explore future scenarios with non-idiomatic technologies without spending more resources than it would take to build a functional prototype?***

We need to address these two questions, establishing animation-based sketching as a distinctive way of reducing uncertainty in the design process and as something that is qualitatively different from video sketching and video prototyping (but which might be combined with them). In order to so, we must take a step back and reflect upon the specific qualities of animation. The contributions we have reviewed so far have not touched upon how animation differs from video, other than its ability to create 'special effects'. This is too limited if we are to understand the role of animation in design sketching. Consequently, in our attempt to develop a more sophisticated understanding of animation-based sketching, the next chapter details the history of animation as a concept and grounds the various definitions of animation.

CHAPTER 4
ANIMATION - THE ILLUSION OF LIFE

In this chapter, we discuss what animation is and what it is not. This discussion includes a basic ontological description of studies of animation. The chapter presents previous arguments and debates about the nature of animation and attempts to free these arguments from the common preconception that associates animation with animated storytelling and film-making. This association has resulted in a blurring of definitions. The goal is therefore to identify a concept of animation that is ontologically precise yet still sufficiently open to include broader applications of animation such as design sketching.

We draw on the review to define animation as the process of deciding and manipulating the differences between a set of graphical positions with enough difference between them to produce a sequential illusion of apparent motion or change. We further investigate how animation-based sketches must adhere to 'second order realism', adhering to the ontological laws of reality to some extent but not attending to too much detail in orthodox physics. Animation-based sketching will be categorised as a 'developmental' genre of animation placed between the orthodox and experimental genres of animation.

We conclude the chapter by reviewing experiments in facilitating formal learning by using animation. On the basis of these studies, we argue that animation generates more information than static imagery due to its temporality: pacing, rhythm and audience anticipation add more to the sum of the animation than the sum of the individual frames per se. Furthermore, animation can provide novices with the means to mentally simulate the future implications of a system. This is the scope of animation-based sketches as a means of visually communicating proposed concepts.

THE SEARCH FOR TEMPORAL EXPRESSIONS

The term 'animation' originates from the Latin word 'animatio', meaning *'Action of imparting life'*, or *'A bestowing of life'* (Wells 1998). The word *'anima'* is also familiarfrom Latin: it is a noun meaning *'soul, spirit or life'* from the verb '*animare*' meaning '*vitality*'. Most people today understand animation in terms of cinematographic animation, which stems from 1912 and describes a specific technical process (Wells 1998). The derivatives of the verb *'to animate'* are *'animates, animated, animator, animating and animation'*. Wells noticed that the verb is currently used in a variety of situations apart from the action of creating a cartoon. For instance, the term 'animatic' is frequently used by practitioners to describe a visually presented *'timed storyboard'*, but animation can also include static layout drawings or animated 'key poses' in a static sequence. At the other end of the spectrum, the term 'animatronic' is used to describe 'puppets' that are controlled electrically, electronically, mechanically or pneumatically to emulate life-like movements (Wells 1998). The uses of animation vary greatly and indicate that the concept of creating change or motion in the inanimate covers a range of actions that is much broader than merely making drawings into cartoons.

From cave paintings to mechanical creating of apparent motion

The ability to give life to the inanimate and to grasp the temporal nature of reality has been valued throughout the ages of human civilisation, thus considerably predating the live action film. In fact, some early palaeolithic cave paintings from the last ice age apparently attempt to capture the phenomenon of motion in still drawings, where the limbs of the depicted humans and animals are portrayed in multiple sequences of superimposed positions, suggesting an attempt to convey the perception of motion (Curtis 2006).

Figure 16: Early cave paintings, depicting hunts of bisons. The multiple drawn legs in different positions has been interpreted as early attempts to portray motion.

A famous example of early attempts to convey motion is the Ibex goblet, which dates more than 5.000 years back (Bendazzi 2015). The goblet has five images depicting a Persian Desert Ibex eating leaves from a tree, by jumping and down.

Figure 17: The artwork from the Ibex goblet drawn out in a cartoon like strip to show the clear expression of the ibex's action taking place over time.

While this series of images and similar examples from other ancient cultures are not animated motion, they indicate a clear early ambition among human cultures to be able to portray the temporal aspects of phenomena. In the late 19th century, renewed interest in creating motion in the inanimate was spurred by the development of photographic film and the ensuing optical experiments with light and human visual perception (Bendazzi 2015). Devices such as the phenakistoscope, zoetrope, praxinoscope, and the common flip book became experimental audience spectacles by creating the illusion of movement from a sequential drawings. In 1892, Charles-Émile Reynaud's 'Théâtre Optique' allowed him to present his animated short 'Pauvre Pierrot' in Paris (Reynaud 1892). It was the first time animated motion had been projected onto a screen, not trapped inside the illusory device itself.

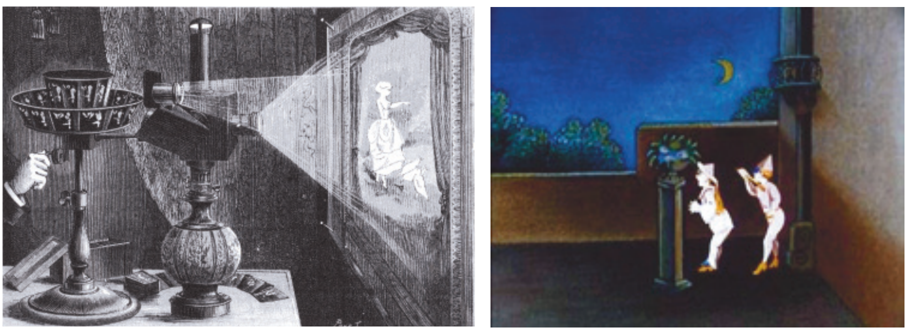


Figure 18: The Théàtre Optique by Reynaud (left), the playback device used to render the animated cartoon 'Pauvre Pierrot' (right) in 1892.

In the following years, the development of the first real motion picture projectors, the art of film recorded animation, and the principles for creating animations developed in tandem with the new movie industry, sharing many of the same storytelling and visual language techniques (Wells 1998).

The gestalt foundation of apparent motion

In 1912, Max Wertheimer's seminal work provided the foundation for creating the perception of motion - making the inanimate come to life. Wertheimer uncovered two different aspects of motion perception: *Beta movement*, and the *Phi phenomenon* (Wertheimer 1912). Beta movement occurs when images are shown in quick succession and the brain registers a difference in the images as movement. Wertheimer showed that the optical illusion due how the eye's optic nerves responds light 10 times per second, and that changes twice this speed are perceived as being in motion, and not as separate images. The phi phenomenon is related to beta movement, but it only exists at higher speeds of changing lights in which we perceive constant movement instead of a sequence. If images are shown changing at a fast enough rate, the brain supplies information that is not there and produces the perception of constant flowing motion. This is what gestalt psychology labels '*apparent movement*' (Wertheimer 1912), and is a product of these two illusory forms of visual perception, and together they are the fundamental mechanisms behind animation and projected movie film. Whenever we refer to animation in the remainder of the book, we are talking about the application of beta movement and the phi phenomenon in creating the illusion of movement over time. Taken alone, however, this gestalt psychological explanation of how animation works has proved inadequate as a definition of 'what animation is' in the discourse of studies of animation.

LESSON LEARNED

Animation is the ambition to ***artificially create apparent motion*** and change, which is enabled by the gestalt phenomenons of beta movement and and phi phenomenon.

The remainder of this chapter therefore explores various attempts to describe animation and discusses them in relation to a definition of animation that is applicable across multiple sites of study. First, we will examine the identification of a 'medium that is specific for animation'.

MEDIUM (IN)SPECIFICITY OF ANIMATION

Much of the power of an idea is inherent in its representation (Victor 2012), since the representation enables us to think the idea - and to think with it. Representations require a medium to carry them, and the production of powerful representations and powerful mediums for representations is among the main drivers of the intellectual development of humanity, allowing us to 'think bigger thoughts' (ibid). If we follow the notion of the 'illusion of life' or even just 'apparent motion over time' as the ambition for the representational capacity of animation, the next challenge involves pinpointing a medium that is specific for animation.

The history of animation indicates that this art form can exist in almost any kind of medium. The illusion of apparent movement can be achieved using clay, paper drawings, cut-outs, puppets, pixelated humans, or digital 2D and 3D. In this regard, Walt Disney's notion of animation as the conceiver of everything we could possibly imagine seems reasonable – the only restriction on animation is the capacity of the mind that is creating it.

Figure 19: Multiple techniques used for animation. Claymation (top left), Motion capture (top right), Stop motion (bottom left) and pixelation with the human body (bottom right)

As a consequence of the breadth of enabling mediums, it makes little sense to claim one medium as being specific to animation. That is, unless we follow the popular notion of animation being seen as equivalent to animated film. In that case, the computer would today be the medium of animation. Almost all animated films today are created using computer animation in some instance. But before the development of digital animation, animation used to drawn, and then transferred to film perforation. Thus, even the recording medium cannot be defined as the specific medium of animation. Thus, history teaches us that it might also be unwise to claim the computer as the specific medium of animation, since it too might be rendered obsolete by new enabling technologies for animation.

The attempt to define the medium of animation seems to be dead end. Animation can be done with both digital, as well as analogue means, from advanced software to flipping pages of paper. If the beta movement or the phi phenomenon can be created, animation can be realised in an moving piece of material.

It may be more fitting to address animation by leaning on Brian Wells' (2011) principle that animation is always a visual form of communication; that is to say, we cannot imagine animation without some sort of visual expression being manifest. From this point of view, animation encompasses all types of visual expression and does not involve a sense of been rooted in one specific medium. This should properly be considered one of the strengths of animation if the ambition is to harness it to explore the potential of technologies and user experiences which do not yet exist. As a collection of possible visual expressions, animation is a way to represent the previously unrepresentable by manipulating time and motion via the visual medium best suited for communicating the specific idea.

ANIMATION IS NOT MOVIE GENRE

An often-repeated preconception in many animation studies is the suggestion that animation is a movie genre (Wells 1998, Furniss 1998, Israel 2007). A genre exists within a certain form of expression. For example, several genres exist in literature: crime drama, adventure, romance, science fiction, etc. Painting includes portraits, landscapes, still life, etc. Live action cinema comprises westerns, soap operas, war pictures, etc. "Genre" is a very broad concept, and we will not attempt to review the concept in all of its variety in this book. In very simple terms, however, a genre can be seen as a deal between the manufacturer and the user, that is, as the users' guarantee that a specific product will satisfy some of their specific requests (Devitt 2004). If the user wants space ships, aliens, and far-away exotic planets, the user selects a science fiction movie. If instead the user wants to be scared and thrilled, the product requested will be a horror or thriller movie. The familiar idioms of specific genres mean that genres are repetitive and therefore reassuring for the user. In that case, animation is not a genre of movies in itself, but a style of filmmaking that can encompass as many genres as live action.

Many genres exist within animation, and thus we will not treat animation as a genre or macro-genre but as a separate style of production that is related to live action production. To some extent, animation uses the visual language of live action cinema as novels use words. Animation conveys meaning and communicates abstract ideas such as emotion and experience, and it does so over the course of time by representing lines, shapes, colours and symbols - giving pace, rhythm and anticipation through apparent motion (Block 2007). Together with, or with absence of, sound, it can represents ideas an evoke emotions in the viewer, crafting an experience.

Live action cinema captures an image of reality that closely relates to what we see in our everyday lives, in a more or less extreme variant. In contrast to this relatedness to everyday life, animation can abstract concepts in a form that could not exist in the physical world. Through aesthetic and functional choices, the animator is able to condense, enhance, and even exaggerate meaning. For example, the use of a certain colour palette and rendering of iconographic characters can break the barriers of what we normally perceive as reality and open our minds to assimilate ideas in a different way. This is what animation inherits from the classic cartoon comics: 'amplification through simplification' (McCloud 1994). When we abstract the idea of a concept in a simpler animated representation, we are not so much *eliminating* details as focusing on *specific* details. Stripping down a representational style to its essence amplifies the meaning in a way which realistic live action cannot achieve. With the gestalt manipulation of time and motion, this amplification becomes even stronger, since it is not only the details of the multiple states of a concept which are amplified, but rather the entirety of the transitions between the states (Buxton 2010).

Brian Wells sees this in terms of a principle of consistency in animation:

> *An animated performance must remain absolutely consistent, exactly as its creator committed to creating it, throughout all viewings and screenings. If the animated performance changes in any way, from how it was initially created, the artistic integrity of the animated performance is lost, and the animation has the potential to be interpreted very differently than how its creator(s) intended.*
>
> Wells, 2011

While clearly aiming to characterise the artistry behind animated film, Wells actually communicates an important point about the *communicative intent* that is present in all animation. If animation is *always* apparent motion created with a specific intention, this indicates that while animation may not be a specific genre, it cannot escape the communicative intent of the author.

Since the viewer can focus upon more specific representations, animation helps the viewer to process the depicted without being closely attached to 'real' world. This relates to a point made in our introduction: Stephenson's (1973) key difference between animations and classic film is that animation offers the producer the ability to exercise near full control of the material matter. As well as being a strong representational style, animation also involves multiple mediums.

We argue that this is what places animation in a strong position to eliminate the prejudices which people lodge in reality and the present state of world, thereby enabling the representation of different perspectives on the future. However, we still do not have a clear basic definition of 'what animation is', which continues to challenge our ability to precisely articulate the expressive capacity of animation.

ANIMATION IS NOT JUST ANIMATED FILMS

One of the first attempts to subject animation to systematic academic scrutiny was Donald Crafton's book *Before Mickey* (Crafton 1993). Crafton made the important claim that instead of looking at modern animation as a remediated cartoon strip, we should seek the 'modern' in the experimentation with special effects and trick photography of pioneers such as Georges Méliès. Furthermore, Crafton was one of the first authors to critically analyse the way in which many of the popular ways of understanding animation relate more to applied production techniques than to the inherent qualities of animation. That is to say, animation studies often analyse the specific aesthetics rendered possible by a given technique, but they rarely analyse the foundation underlying the use of apparent motion in the first place. Despite Crafton's work, this fallacy of relating description animation to its 'specific' technology or production method was carried over into some of the first academic attempts to define animation. For instance, Small & Levinson (1989) defined animation as simply 'frame-by-frame recording' or 'single-frame cinematography' (Small & Levinson 1989, 68). Charles Solomon formulated a contemporary definition, stating that animation is special due to 'the illusion of motions created (designed) rather than recorded as in live action film' (Solomon 1987). Besides focusing on the production technique, both of these definitions fall into the trap of defining animation by how it compares to live action film; in essence, this amounts to a definition which is based on what it is not. In line with both Small & Levinson and Solomon, the acclaimed animation researcher Paul Wells falls into the same trap in presenting his working definition of animation: "*it is film, made by hand, frame-by-frame, providing an illusion of movement which has not been directly recorded in the conventional photographic sense" (*Wells 1998*,* 1).

There are a problems with such definitions of animation as being the non-recorded illusion of motion and as frame-by-frame production. On the production technique side, these definitions are simply too limited in terms of modern animation techniques. For example, computer animations creating the illusion of motion are not animated frame-by-frame, but rather through a set of variables and keyframes which automate the creation of motion. We shall address the issues of computer animation later in examining the creation of digital animation-based sketches, but for now this critique indicate how the previous definition fails to include computer animation in its scope.

Brian Wells gets around this problem by adding yet another principle to his descriptive analysis of animation. As Wells notes,

> *"Animation is comprised of a sequential set of still images, each recorded for a discrete unit of time, and these discrete units of time are displayed in relatively rapid succession in order to achieve the illusion of lifelike movement or change. "*
>
> Wells, 2011

Wells modifies the limitation inherent in the definitions provided by Small & Levinson and Solomon by simply stating that while animation does indeed consist of a sequence of still images, they have not necessarily been recorded frame-by-frame, but rather in a *discrete unit of time*. This means that the production technique of animation can vary, as long as the output can be displayed in succession to achieve apparent motion. However, as Wells argues, this is also partly true of live film footage. This leads him to adopt the perceptual concept of 'short and long range apparent motion' from Anderson & Anderson (1993), in which 'long range' describes the fluent nature of 'real' motion, and 'short range' describes the way in which animation, no matter how detailed, will always appear somewhat disjointed compared to reality.

As already mentioned, there is a broad area in which live action and animation overlap, especially in terms of aesthetics - for instance, cuts, angles, and light setup. Rather than seeing the two as existing in separate categories, Maureen Furniss (1998) argued that it would be more accurate to think of them as placed in a continuum. This continuum would represent all possible types of images as 'motion picture production'. At each pole, the continuum uses more neutral terms than 'animation' and 'live action', replacing them with '*abstract*' and '*mimesis*'. Mimesis represents the desire to reproduce natural reality, and abstraction describes the use of proto-forms, thus suggesting a concept rather than an attempt to explicate it in real form. The placement on Furniss' continuum is somewhat arbitrary - there is no one specific spot for a specific example to be, but rather a relation between different placements.

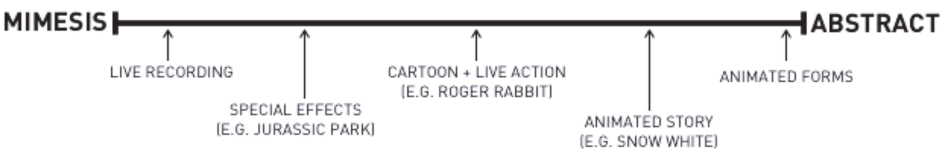


Figure 20: Furniss' (1998) continuum of moving picture types, ranging from the purely mimetic, to the purely abstract artificially apparent motion of abstract forms.

The difference between a continuum and a hard definition is that the continuum uses similarities to position items in relation to one another, while a definition seeks differences to separate items from each other. Furniss's goal is an aesthetic view of animation, which is why the continuum approach works. For instance, the continuum helps to show the relation between the use of animated special effects in a live action movie such as 'Jurassic Park' and the animation of a cartoon such as 'Bugs Bunny'. While this is a great strength, and while the continuum will be revisited later in this book, Furniss still implicitly distinguishes between real live action and the artificially animated. Thus, the continuum still relies on the reader's ability to understand when something is animated and when it presents live recorded events. We still need a fundamental definition of animation that can fit into Furniss's continuum but is independent of the production techniques used, thus accommodating both classic frame-by-frame manipulation and modern computerised animation.

MOVEMENTS THAT ARE DRAWN - OR DESIGNED?

In the 1950s, animation veteran Norman McLaren offered what has become one of the most quoted insights into animation. He suggested three defining characteristics of animation:

> *Animation is not the art of drawings that move, but the art of movements that are drawn. What happens between each frame is much more important than what exists on each frame. Animation is therefore the art of manipulating the invisible interstices that lie between the frames.*
>
> Quoted in Sifianos (1995)

There is a significant depth in McLaren's way of describing animation. First, while he points out that animation happens during the 1/24th of a second between the frames of film, he is also referring to the way in which human perception quickly integrates, evaluates and communicates the most subtle changes in time and space. The properties of animation that McLaren notices provide the animator (or designer) with the ability to simultaneously control both time and space and to use them as media for creative expression.

Furniss, Wells and Solomon quote McLaren's notion of animation, but they develop their definitions or categorisations in directions that diverge from McLaren's original statement, perhaps because the anecdotal nature of McLaren's statement remained outside any academic or even popular publication. However, on the basis of correspondence with McLaren in 1995, George Sifianos published an in-depth explanation of McLaren's characterisation (Sifianos 1995). First, Sifianos corrected the notion that 'a drawing' could be interchangeable with any kind of 'moveable medium', and the idea of drawing motion is even partially discarded as being yet another 'definition based on production technique'. The essential quality of the first characteristic, however, is that it frames motion as the essence of animation, independent of the drawing medium or technique. Motion or change as the essence of animation is further elaborated in McLaren's second and third characteristics of animation. The real essence, is expressed in the second and third defining characteristics, which state that the most important characteristic of animation is the way in which the animator moves the figure between each frame. This is a slightly different definition from the type proposed by Solomon and Small & Levine, since, like Wells principle, it does not limit itself to frame-by-frame recording; instead, it addresses the decision making process of what needs to happen between a succession of frames. As such, it constitutes a definition not of the practice of animation, but of the essence of animation.

McLaren's characteristics encompass five basic categories of animated motion: (1) zero motion, (2) constant motion, (3) accelerating motion, (4) decelerating motion, and (5) erratic/chaotic motion (Sifianos 1995, 64). The animator has to decide how much to move between shooting one frame (or sequence of frames) and the next. In McLaren's words, that critical decision is 'the heart and soul of animation'. The difference between each successive frame is to the animator a more essential aspect, than the graphical expression (the graphism) on each individual frame. Animation, therefore, is *"the manipulation of the differences between successive frames' constituting the animator's operation"* (Sifianos, 1995, 66). This effectively provides a definition of animation which is not tied to the notion of animated film, which does not conflict with modern animation practices using digital computer animation, and which is strict enough to constitute a fundamental quality, while still being broad enough to fit Furniss's notion of the continuum between mimesis and abstraction. It also indicates that 'motion' and 'change' are both properties of animation. A thing can move according to McLaren's movement categories, but it may also erratically change; for instance, it might simply disappear. The succession between discrete units of time in animation is thus not just movement, but all kinds of change manipulated between the frames.

McLaren's final definition also makes an important ontological distinction between creating artificial motion or change and creating artificial expressions - what McLaren calls 'graphism'. This division effectively helps us to understand animation as the process of artificially producing motion or change, while, depending on the expressive material, it falls to other disciplines to construct the imagery that is to be 'moved'. That is to say, designing animation, and designing graphics, for example, are not the same thing. Consequently, the quality of the temporal sequence must be assessed independently from the quality of the visuals. Moreover, 'designing motion or change' is the essential design craft of animation. Animator Richard Taylor noted that *"It is possible to make a bad film with beautiful drawings or models - the art of animation is in the action"* (Taylor 2003, 7).

Drawing on Sifianos's published conversation with McLaren and the critique of medium-specific or genre-specific definitions, we suggest a broad definition of animation and the creation of apparent motion:

ANIMATION IS:

The process of deciding and manipulating the differences between a set of graphical positions, with enough difference to produce an sequential illusion of apparent motion or change.

This working definition of the fundamental essence of animation will be our point of reference as we move towards pairing animation with design sketching. To stay true to the sources from which we gather new perspectives in our further review, we continue to use the eclectic mix of the concepts of 'animation', 'animated film' and 'animation genre'. In doing so, however, we use a definition based on McLaren's, and we do not attempt further approximations to the concept of animation itself.

CLASSIC ANIMATION FEATURES IN ANIMATION-BASED SKETCHING

The first step in defining animation-based sketching as a distinctive approach is a discussion of how the traditional studies of animation might inform a design sketching perspective. Thus, we start by expanding on our established definition of animation and examine which aspects of traditional animation are inherited by animation-based sketching.

Thompson & Johnson argue that the use of abstractions of reality in animation adheres to the aforementioned principles of 'amplification through simplification' (McCloud 1994) by tapping into the basic encoded visual language of human beings. They refer to this as the (potential) ability of animation to reach almost any audience, regardless of language barrier: communication through animation is based on the symbols that all human beings can understand because they go back before we developed speech. According to Thompson & Johnson, the universality of the visual language of animation is the basis for Walt Disney's famous note about the expressive capacity of animation.

> *"Animation can explain whatever the mind of man can conceive"*
>
> Walt Disney in Thompson & Johnson (1981)

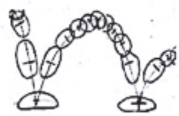
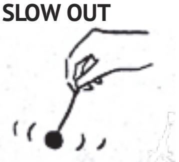
Disney's notion reflects the ambition to position animation as the center piece of imaginative expression. This ambition helped transform animation into a significant industry. Unlike live action film, animation is more unrestricted, and draws from a raw material that is essentially entirely made up. It is the how animators imagine and combine ideas about the forms, movements and meaning of things constitute animated expression (Bendazzi 1994). Animated films create a narrative and visual space, that are potentially very different from what live action would portray. Whereas live action films seeks to present physical reality, the ambition of the early animation industry seemed to be to deal more with a meta reality. That is not, how reality looks, but what it means. The animated film here connotes escapism and unambiguous visual emotions (Wells 1998).

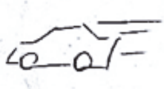
Unlike live action storytellers, however, the animator faces the challenge of capturing the subtlety and aliveness of an artificial reality via symbols that are culturally related to the emotions and actions depicted. Issues often arise which are difficult to formalize, such as the representation of the chemistry between actors. In live action, the canvas is never blank as it is for the animator. In the pioneering work of the Disney Studios, this 'abstraction gap' was overcome by leveraging upon what Disney labelled 'audience involvement' (Johnston & Thomas 1995). When telling a story, regardless of how abstract the story would end up being, the animator would start with something the audience knew, liked, and could relate to in using their experiences as human beings to fill out the gaps in the abstraction. Consequently, the animated product would seem to come 'alive' and appear 'real' through the indexical link between real world experiences and imagination. Early pioneering film-maker Sergei Eísenstein recognised Disney's achievements in animation as achieving a particular effect: "*...if it moves, then it is real - moved by an innate, independent, volitional impulse"* (Leyda 1988, 54). This aliveness gave animation its particular enigmatic quality of creating 'the illusion of life'.

The early contributions of Disney studios (founded in 1923) helped create the foundation for the entire animation industry, cemented by the first full length animated feature film, Snow White (Cottrell et al 1937). Even though Disney Studios had already experimented with the scope of animation, it soon became fixated on verisimilitude in its productions, conforming to a mode realism concordant with that of live- action film-making (Wells 1998). Johnston & Thomas (1995) recount the early history of Disney studio as Walt Disney's search for established principles or idioms of apparent movement to establish animation as an art form on a par with live action movies. This is what Paul Well's (1998) called the ambition of *hyper-realism*, which, due to the success of the Disney studio, defined the orthodox genre of animation. Through Disney

Studio's accumulation of experience, the complex process of creating 'the illusion of life' was gradually condensed into specific principles. Johnston & Thomas (1995) elaborate them in their summary of the '12 principles of animation', which they describe as a reflection on the practice from Disney's animation process, developed from earlier prototypical and less life-like principles (Johnston & Thomas 1995, 48).

See next page for the 12 animation principles.

1) SQUASH & STRETCH 	“Squash & Stretch” is often seen as the most important principle, it describes the illusion of weight and volume of an object, and defines how rigid an object it, by how its volume is affected by movement. Squash and stretch is especially useful animating dialogue and movements of the face. The extent of squash and stretch is affecting many of the other principles, since this foundational physic invokes much of the more emotional animated expressions.
2) STAGING 	Staging is not in itself about movement. It involves presenting the animated scene so that is unmistakably clear to the audience where it should direct its attention. In animation, this principle has been essential to establishing correct perspectives, light, and field of views for the actions to be perceived as intended.
3) ANTICIPATION 	Anticipation means preparing the viewer for actions about to happen, such as initiating a jump, speaking or waving. Once again, this principle is not related directly to the creation of apparent motion; it guides attention. Whereas staging is about the entirety, anticipation is about the specifics and finer details.
4) STRAIGHT AHEAD & POSE TO POSE 	This principles is actually two different approaches to the production of animated graphics, and thus not principles of movement themselves. With “Straight ahead action" the scene is drawn out from beginning to end, and in "pose to pose" so-called key frames are drawn to define positions, an the ‘in-betweens are then filled in later.
5) FOLLOW THROUGH & OVERLAPPING 	These two techniques address motion physics, especially motion inertia. "Follow through" describes how parts that are loose continue to move after the object stops moving. "Overlapping action" is describes parts of an object that move differently, depending on the center of gravity.
6) SLOW IN & SLOW OUT 	Time is stretched to emphasise actions or to make actions adhere more realistically to the physical laws of acceleration and deceleration. As an action starts, more positions are drawn near the start, with few in the middle, and more positions right before the next pose. The amount of positions determine how fast or slow an action is.

7) ARCS 	Most motion in reality follows arched trajectories; this principle involves recreating such arcs artificially. This principles is another physics oriented principles, urging the animator to analyse the nature of the object animated in order to make the motion adhere to 'implied' arcs of motion, e.g. by joints or parabolic trajectories.
8) SECONDARY ACTION  	This principle involves showing the action of and object resulting from another action. This is linked to anticipation and staging as it involves linking different points of attention for the audience. Critically, secondary actions should emphasise the main action rather than take attention away from it.
9) TIMING 	Timing has to levels in animation. Physically, timing is about how an object adheres to the laws of physic - e.g. how weight affects momentum. Dramatically, timing prepares and delivers actions by adjusting them in accordance to the 'personality' of the object represented.
10) EXAGGERATION 	This involves accentuating the essence of an idea by the animated action. It often exaggerates timing and the geometric deformation of objects. Since exaggeration can greatly affect the style of an animation for dramatic and comedic purposes, this is one of the most variable principles of animation.
11) SOLID DRAWINGS 	Solid drawing states that the 3-dimensional space representable through graphical forms must be taken into account. Thus, this principle concludes the physical principles by emphasising the role of perspective in the graphics of object appearance.
12) APPEAL 	An actor can be said to have charisma. An animated character (or object) has appeal. Characters have appeal whether they are heroes, villains, comedic or sad. This principle essentially denotes that all animation will have some sort of appeal, and thus states that a certain view of that appeal should be enjoyable (Thompson & Johnson 1981, 68)

Evident in the 12 principles of animation is a clear division between principles which establish how to animate in a life-like manner (1, 4, 5, 6, 7, 9 and 11) and principles which emphasise the emotional design of likeable characters and the aesthetic appeal (2, 3, 8, 10, and 12). Thompson & Johnston recognise this division in their description of how the exploration of characters and objects essentially is *"...to make the audience feel the emotions of the characters, rather than appreciate them intellectually"*. In film and in any type of storytelling, realism is relative and subjective (Wells 1998, Bordwell & Thompson 2010). The film-maker shows so-called subjective realities more persuasively while grounding this representation in photographic realism as its clear indexical link to reality. To a great extent, Disney studios aligned animation with this realism and only partially considered the more abstract qualities of animation to create the artificial illusion of motion in all its possible forms.

Wells has related this characteristic to Umberto Eco's notion of '*hyper-realism*' (Eco 1986): it is fake due to the that it does record reality with a camera, but artificially creates its own. Viewing the 12 principles of animation as principles for hyper-realism has a range of consequences, evident in how Disney, and other studios who emulated the studio style informed their animation process. For example, the design, characters, contexts and actions had to be subject to the ontological laws of 'the real world' to some extent, and they therefore corresponded to the representation of reality in live action films. Further, the creation of movement itself had to correspond to the possibilities inherent in orthodox physical aspects of human beings and objects in reality. Wells also argues that despite these links to the ontology of reality, hyper-realism is neither a strictly accurate version of reality nor a radical abstraction of the animated form, but rather what he labels a 'second-order realism' (Wells 1998, 27).

In this sense, it might be argued that despite Disney's hyper realistic ambition, animation always avoids and resists realism, and thus can more accurately be said to be 'about realism'. As such, animation plays a rather metaphysical role in portraying ideas. Whereas the fundamental goal of live action films is to present physical reality in real or imagined forms, animation is concerned not with how things are or how they look, but with what thing could be and what they mean. Thus, the domain of animation-based sketching has inherited from Disney's hyperrealism the recognition that while we orientate the animation of our ideas towards the reality of our world, an animated sketch will, to a certain degree, always costitute a 'second-order realism'. This implies that while we need to address the ontological laws of reality, we need not necessarily prioritise strict adherence to the orthodox movements and physical aspects of objects.

On the basis of Wells' analysis, it may be argued that following the success and maturation of animation through Disney's work in the late 30's, hyper-realism became the dominant discourse of animation to the point where Disney's animation principles were nearly synonymous with animation. Wells labels the genre of hyper-realism in animation 'orthodox animation' and compares it to more art-based and abstract 'experimental animation' in his final framework of animation:

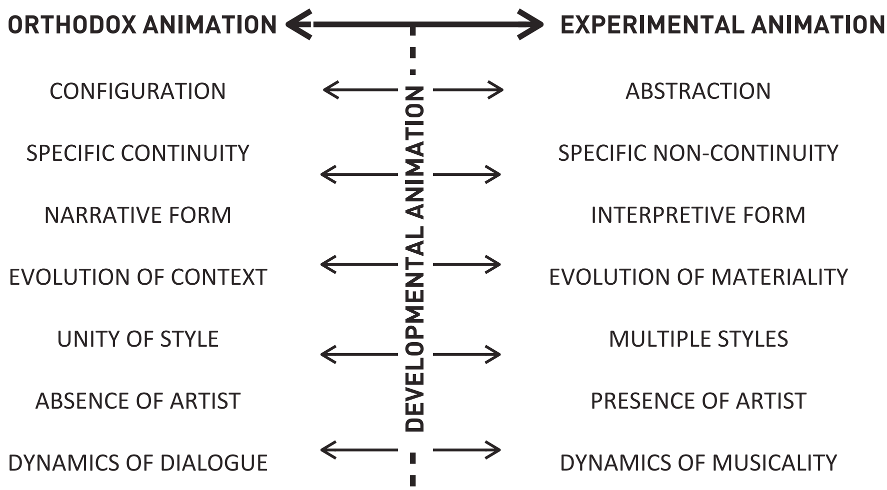


Figure 21: Well's division of animation genres set between orthodox and experimental animation, whereas the orthodox genre corresponds with the left half of Furniss' (1998) continuum, and the experimental with the right half of the continuum's abstract style. In the middle, Wells places developmental animation as a combinatory genre, which combine, and mix styles of both orthodox and experimental - a fitting match for sketching?

Wells adds an interesting division between the two. He proposes a middle-ground which he labels 'developmental'. This middle ground leverages selected aspects of both domains in a flux that informs the evolution of principles for both orthodox and experimental animation. As stated by Wells, *"Developmental animation, by definition, harks back to traditional aspects of the animated film but also seeks to embellish or reform these traditions with contemporary approaches"* (Wells 1998 51). This category seems to be the obvious ontological space in animation studies to place animation-based sketching. Animation-based sketching as a ‘developmental animation’ approach illustrates, for example, how the approach might combine multiple styles and mix narrative and interpretative forms without the need to supply a specific genre label or to stipulate a specific medium.

However, we must not forget that Wells’ framing is rooted in his definition of animation as something that is tied to ‘film’; some aspects of the framework will be ill-suited for distinguishing animation in general. What the framework division does show us, however, is that throughout its evolution, ‘traditional’ animation used for entertainment or art has been influenced by both orthodox and experimental ways of addressing motion. This helps us draw a line connecting the earliest examples of developmental animation to the ambitions inherent in contemporary animation-based sketching.

Early developmental animation was used by the likes of Georges Méliès. Méliès used animation combined with live film to create ‘original effects’ (Wells 1998) which were outside the physical reality of our here and now but which to some extent still sought to conform to the basic ontology of reality. His now famous ‘Journey to the Moon’ (Méliès 1902) is a classic example, showing the potential of space travel on the basis of the technological and astronomical knowledge at the time, long before it become a reality. A similar example was one of the earliest uses of cartoon animation in Winsor McCay’s ‘Gertie the Dinosaur’ (McCay 1914), in which McCay appears to enter the film from the physical stage, thus providing an example of what would become a continuing discourse between animation and live-action film in the early years of the medium.

Figure 22: Stills from the early pioneering motion pictures. Méliès ‘Journey to the Moon’ (left) using early stop motion cutting techniques, and Mckay’s ‘Gertie the Dinosaur’ simulating the mix between live acting and cartoon animation (right)

These early examples of animation showcase the fundamental developmental ambition of early animation to expose the limitations of representing 'reality' on film and to use animation to free itself from these limitations in portraying 'the seemingly impossible'. This idea is backed by Holloway's (1972) reference to the Zagreb school of animation and their idea of animation as "*a way of giving life and soul to a design, not through the copying of reality, but through the transformation of reality*". The early developmental movements in animation thus emerged as a representational tool to think and reflect about artificial phenomena that we would be unable to understand without the temporal information from animation. With this in mind, we will argue that, since its earliest development, animation has actually been a movement that correlates with the ambition of design sketching: it creates information about the world which did not exist before so that we can explore it and reflect upon it. Animation adds a layer of temporality to artificially created graphics, and, as Fallman & Moussette (2011) point out, it creates vital information about crucial aspects of the interactions and dynamics of the design of digital technologies.

Thus, animation-based sketching takes its cue from animation history and becomes the driver behind imagining 'seemingly impossible things' by drawing upon experimental qualities, on the one hand, and, on the other, by drawing on its orthodox qualities as the mediator connecting it to reality. The question is whether this expressive capacity is also able to facilitate and inform new design knowledge. In other words, can animation facilitate?

LESSON LEARNED:

Animation-based sketches must adhere to ***'second order realism' -*** adhering to the ontological laws of reality to some extent, but not attending too much detail in the orthodox physics details

Animation-based sketching is to be categorised as a ***'developmental' genre*** of animation

ANIMATION-BASED SKETCHING - A LEARNING TOOL?

The majority of research done on the facilitative capabilities of animation has not been conducted within the domain of design studies, but in the study of facilitating learning. Consequently, we review the contributions in this field and examine the conclusions drawn in facilitating learning in light of the ambition of using animation to facilitate explorations within the design domain.

Pictorial languages as facilitators

As we learned previously in this chapter, history shows that mankind has long had the ambition to portray temporal information, starting with the use of static images to showcase motion and dynamic concepts. Understanding artificially created imagery, or 'graphism' as McLaren (Sifianos 1995) called it, is therefore a fundamental part of understanding animation. This is due to the ubiquity and naturalness of graphic representations used to represent abstract concepts across cultures (Tversky et al 2002). Such *pictorial languages* can be found across the world and throughout the course of human history (e.g. Gelb 1952, Dege et al 2001, Mallery 1972). The manner of schematising people, animals, and contexts shows striking similarities across cultures.

The research into the role of static graphical elements as facilitative tools for learning is rather comprehensive, and has indicated that only carefully designed material can actually be beneficial (e.g. Tversky 1997, Larkin & Simon 1987, Scaife & Rogers 1996). The major division is between the use of graphics to portray inherently visuospatial information (a building, living being or any other material object) and to present what is metaphorically visuospatial (for instance, graphs, flows, and organisational charts). The assessment of graphical representations is based on the natural cognitive correspondence between the real world and the depiction - the way in which the pictorial language enables us to see a given visuospatial expression as the sign for something in reality. This is expressed in what Tversky et al (2002) label the *Congruence Principle* for effective graphics: *the structure and content of the external representation should correspond to the desired structure and content of the internal representation*. This principle indicates that the driver of graphical depiction is not the creation of realism, but the creation of a *runnable mental model* of the depicted (Mayer 1989), in which the depicted phenomenon can be distorted if this helps us to understand its essence.

Can animation facilitate learning?

Tversky et al (2002) suggest that according to the congruence principle, animation might be expected to offer a compelling way to convey concepts of temporal change, just as static graphics are natural for conveying space. However, the authors argue that this is not necessarily the case, and they set out to investigate whether animation facilitates better learning than comparable static imagery. They review a large selection of research on the use of animation in learning situations, including teaching of the water circulation (Large et al 1996), of Newton's Laws (Rieber 1990), electronic circuits (Park & Gittelman 1992), and mathematics (Thompson & Riding 1990). All the reviewed research claims that the animated content created stronger comprehension than the static imagery. Nevertheless, Tversky et al criticise these conclusion for being based on what they label *'incomparable content in static and animated graphics'* (Tversky et al 2002, 251). As they see it, more information has been created and integrated in the animated material than in the static imagery, which could possibly also have expressed the information through further graphical details in the static images. They argue, that a lack of equal information in static and animated material makes it difficult to conclude whether it was the illusion of apparent movement and change which alone facilitated the higher degree of learning, or whether it was simply due to the addition of more information.

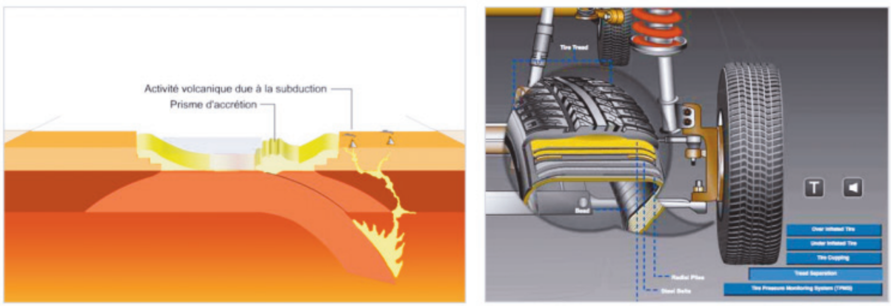


Figure 23: Examples of animations with the purpose of facilitating learning about dynamic phenomenons like plate tectonics (left) and tire mechanics in a car (right).

They add to their critique of the existing research by pointing out examples of how interactivity affects the role of animation when used to facilitate the learning of cistern systems (Hegarty et al 2002), algebra (Nathan et al 1990) and energy systems (Kieras 1992). They discuss how the studies confuse the effect of being able to manipulate variables and experiment with their predictions of how a given concept would work with the effect of animation. Rather than being attributable to animation, the improved learning outcomes of these studies might actually be a consequence of interactivity supporting superior study procedures, which is known to support learning independent of graphics (Schnotz et al 1999).

This leads Tversky et al to conclude that most of the reported successful application of animation in learning situations seems to be due either to extra information presented in animated content compared to the information presented in static forms, or to the addition of extra procedures. They therefore suggest that when the content and procedures are the same, animation might not prove any better than static imagery in facilitating learning.

They do not see this as a fault of the congruence principle, but as cognitive limitations in processing visual change. They label this the *apprehension principle: the structure and content of the external representation should be readily and accurately perceived and comprehended* (Tversky et al 2002). Animations are fleeting and not fixed in discrete steps as static images, and Tversky et al point out that when stripped of the extra information and interactive procedures, the information conveyed in animated material disappears immediately after being presented, removing the ability to reinspect it.

Animation adds an extra layer of information per se

The analysis performed by Tversky et al paints a rather bleak picture of the potential scope of using animation for sketching purposes. Their critique indicates that animation might not provide any more relevant temporal information than we can already derive from static sketches.

All is not lost however, since we will argue that while Tversky et al offer a comprehensive review, it might also be read from another perspective. The authors' primary point is that cases using animation in a learning environment often present better visualisation approaches than static imagery or that they employ superior study procedures such as interactivity. But does that not just state one of the obvious qualities of animation, and of temporal expressions as a whole? The superior extra detail of information in the animation can be related to McLaren's distinction between creating the artificial image and deciding *how much* it should move between each successive configuration. The artificial image itself is static, but combined with the (design) thinking regarding the extent to which it should be configured to portray the desired motion, it naturally conveys more information than could be portrayed in a single image. That is, to paraphrase Buxton (2010) and McLaren (Sifianos 1995), *the experience is in the transition between stages.*

We therefore suggest that the argument that animation provides extra information is valid but obvious. Extra information exists in all animations, but this is simply an effect of the process of creating motion - it provides temporal information, which adds pacing and rhythm to the series of moving images. One might argue that such information could also be conveyed by adding more static images, that is more stages, but it is not a natural part of the static sketching process as sketches involve key frames. By definition, however, animation integrates reflection about what happens between the stages in the animation process, and this makes it more natural to express more information, which of course also increases the production time itself. But even if we drew all the frames of an animated sketch as static images, viewing the sketches would not provide the same temporal information as the animation. This is because browsing through static images cannot convey the pacing, rhythm and anticipation involved in watching something unfold over time. Of course, browsing between multiple states does have its own strengths, but it does not express the same temporal information as animation.

The second critique upon using interactivity, to overcome the apprehension challenge of animation, is viable to the extent that the digital system is based on interactive computing rather than on the animated content itself. However, a critique based on the apprehension principle is arguably too weak, since we can imagine animation being stripped of all unnecessary content to focus exclusively on the bare necessity of creating a running mental model. In fact, it has been a principle of animation since the work of Walt Disney himself:

> *"Walt Disney was basically a communicator, and in animated film he found an astounding potential for expressing his ideas. The cartoon drawing always had been a very simple and direct graphic form, and whether it was for social commentary or just amusement it had to present a unified, single ideas with nothing complicated, extraneous, or contradictory in its makeup. When cartoon was transferred to film these elements still applied, and nothing was drawn that was not part of the idea."*
>
> Johnston & Thomas 1995, 30

The apprehension principle of facilitative animated graphics stipulates that the content should follow the conventional graphic representation in the specific domain and should be stripped of all cosmetic features that are not directly useful for understanding. The critique of interactivity is also somewhat problematic when addressing a temporal expression which, as Brian Wells (2011) notes, is dependent on some type of playback medium. Playback mediums for analogue mechanisms, electronic appliances or digital software features always have the potential to give the viewer some control, with 'on' and 'off' as a minimum. However, features such as 'pause' and 'resume' frequently exist in playback mediums. Thus it seems artificial to require that this aspect should not be considered when evaluating animation as facilitation.

> **LESSON LEARNED:**
>
> Animation generates more information than static imagery due to its temporality - the ***pacing***, ***rhythm*** and ***audience anticipation*** adds more to the sum of the animation, than the sum of individual frames themselves.

In conclusion, it simply seems unreasonable to strip animation of these qualities: animation per se does generate more information, and does enable potential interactive features such as playback control. Such qualities could also be enabled in static imagery, but this is uncommon. Even with more images, static imagery would not be able to express pace, rhythm or sequentiality in the same way that animation does. Learning and instructional material might not always need this temporal information, since it makes use of established idioms instead of actually expressing the dynamics and temporality of the phenomenon. When exploring the interaction design and user experience of a non-idiomatic technology, however, we do not have this possibility; consequently we are in dire need of the temporal feedback offered by the animation-based sketch. Tversky et al, however, do end their paper with the caveat that other instances of animation might prove them wrong in their critique, and they add that, in theory at least, animation could be applied in accordance with both the congruence and apprehension principles.

Animated facilitation is best for novice learners

While we oppose Tversky et al's insistence on denying animation its extra layers of information and its ability to include interactivity by controlling playback, we do acknowledge the importance of their critical scrutiny of the way in which animation enables learning and their inclusion of experiments showing that animation might actually prohibit learning.

Mireille Betrancourt elaborates on this critique in presenting a set of principles for using animation in facilitative learning settings (Betrancourt in Mayer 2005). Like Tversky et al (2002), she is concerned that research into the effectiveness of animation in facilitating learning has given somewhat mixed results: the learning effects of animation ranged from highly beneficial to detrimental. Betrancourt adds an analysis of Catrambone & Say's (2002) study of the use of animation to facilitate the learning of computer science algorithms, in which animation is shown to have a positive impact on performance, but in which benefits disappear when the textual instructions were made more detailed. Drawing on further studies by Catrambone et al (1999) and Hegarty et al (2002), Betrancourt emphasises the role played by interactivity in cases where animation had a positive effect on the facilitation of learning. She expands on this notion by detailing how the benefits of using animation seem to be in correspondence with the learners ability to make predictions. In general, participants who studied using animation did not fare better than those who studied using text and image examples; however, when asked to predict system behaviour, the animation-based learners displayed a better understanding of the system. This indicates that the ability of animation to represent transitions between discrete stages of a phenomenon is facilitative, in that it supports learners who might find it challenging to mentally simulate the future implications of a system from static imagery. This support is enabled by the combined effect of the temporal information generated by the animation and the interactive control mechanisms that enable learners to process the continuous flow of information, without being overloaded. That is, new temporal information about the dynamic system can be processed and integrated gradually into the mental model of the learner (Mayer & Chandler 2001).

However, as Betrancourt also notes, Tversky et al (2002) point out that these studies might not have monitored the control of the variables in their experiment thoroughly enough to isolate the specifics of animation very effectively. The conclusions drawn about the effectiveness of animated learning compared to static imagery are thus rather inconsistent. That is besides the effects interactivity can have on using animation to predict, and the fact that animations contain more information than static images. Betrancourt points to differences in learners' domain specific knowledge, and their visuo-spatial abilities as determinants which could be of importance but which have scarcely been investigated (Betrancourt in Mayer 2005, 291).

Schnotz & Rasch's (2002) categorise on the basis of three functions which are attributed to animation in elaborating a mental model dynamic information: *enabling, facilitating* or *inhibiting*. Novice learners, or learners with low visua-spatial skill, are enabled in visualising dynamic systems mentally when supported by animation. Likewise, Mayers & Sims (1994) found that this benefit was mostly evident for novices, and less so for domain experts. For novices, the ability to mentally simulate and predict the behaviour of the dynamic system, the cognitive load is lower, and it is thus easier to form a 'running mental model' (Betrancourt in Mayer 2005). However, while animation supports the formation of said mental models, the cognitive efforts saved has been found to also potentially induce a more shallow understanding of the deeper content of the learning material - what Schnotz calls an *"illusion of understanding"* (Schnotz et al 1999; Lowe, 2003). In these cases, facilitation of the mental model is actually inhibited by animation. Furthermore, domain experts with well- informed mental models can rely on memory and experience to learn about new complex concepts within the domain, and thus benefits less than novices from added temporal information.

Lowe (2003) provides evidence on, how novices focus attention on what is perceptually dominant rather than on relevant domain features in the animated content. Betrancourt labels this the *attention-guiding principle;* animation is supported by clear visuals and interactive controls which guide the users' focus and enable individual pacing of the material. This relates back to the critical factor of the *apprehension principle* of effective graphics: the aesthetic features should all be conceived in relation to the domain and directed at the functional aspects of *what* the learner should gain from watching the graphics at any given moment. Betrancourt adopts this notion in a reinterpretation of the *congruence principle* for animation-based learning: *changes in animation should map changes in the conceptual model rather than changes in the behaviour of the phenomenon, even if this entails distorting the realism of the phenomenon* (Betrancourt in Mayer 2005, 292).

LESSON LEARNED:

Animation can provide novices the means to ***mentally simulate the future*** implications of a system, which is inferred as also being the scope of animation-based sketches as means of visual communication of a proposed concepts.

Effective facilitative animation is enabled by the ***attention-guiding***, ***apprehension*** and ***congruence principles***.

In the end, Betrancourt's perspective on the facilitative potential of animation in learning is more positive than in her work in Tversky et al (2002), even though her critique is inconclusive when it addresses the range of *when* animation can facilitate learning, and *for whom*. Nevertheless, her analysis indicates the clear potential of animation as a way of improving the understanding of dynamic phenomena involving temporal change. The principles of interactivity, apprehension, congruence and attention-guidance provide a guideline for avoiding the pitfalls that have been identified and may guide the establishment of running mental models via animation. However, while we have been able to learn much from these studies of facilitation of learning by animation, the question remains - are these lessons transferrable to design?

Animation-based sketching is not animation-based learning - it is design!

The topic of discussion in this section has been limited to the role of animation in facilitating formal learning in complex learning systems, such as trajectories, transformations or relative motions. We suggest the term 'animation-based learning' for this type of animation, in which the facilitative aspect of animation is evaluated in terms of enabling learners to either remember, replicate or use the animated content to master a specific phenomenon.

This is rather different from how facilitation is predominantly understood within the domain of design. We follow Löwgren & Stolterman (2004) Nelson & Stolterman (2003), and Fällman (2003) in considering 'knowledge' the main 'product' of design. Design knowledge is primarily intended for other members of the knowledge construction culture to share, debate, challenge, extend, reject, and use. These members include designers, critics, clients, and users. The main purpose of facilitative tools and methods in design is thus to promote the construction of new knowledge rather than to assimilate or accommodate existing formal knowledge. Design as a practice never exists in the here and now. Whether the proposed state is a week or a year away, designers propose propositions what might come if following a proposed path. Thus, design is a contingent practice that operates on the boundaries of reality and, in the classical sense proposed by Simon (1996), attempts to explore its 'preferred state' version. Truth is not as crucial in design as in a formal learning paradigm. In design, an image of reality must be created to frame a foundation for the design process (Löwgren & Stolterman 2004). Since a design situation can be approached from many perspectives (ethical, functional, aesthetically, structural, material, experiential, and so on), a designer makes a contingent decision on what needs to be studied most carefully and on which dimensions of the situation should not be included in the framing. The main point here is that design intervention towards changing reality towards a proposed state. This type of agency is not objective: the designer includes some aspects and omits others from the frame.

We argue that this epistemological difference between animation-based learning and animation-based sketching should make us ask whether it is reasonable to transfer all insights from one field to the other. The principles of apprehension and congruence are transferable insofar as they determine how animation-based sketches should focus on only showing what is needed and allow distortion of the realism of the sketches if the distortion supports explorations of the underlying conceptual model. However they are not transferrable in the extend of the criticism of the divide between novice and expert learning, since the aim of animation-based sketching is not to reveal the inner complexities of *what a phenomenon is*, but rather to facilitate a vision of how the overall user experience of a future state *might be*.

Animation-based sketching is not concerned with reducing the complexity in the details of an idea, but rather with constructing new information to reduce the uncertainty about which ideas are viable in the first place. The divide between novices and experts is thus not as much a concern for sketching as it is for formal learning. The goal is not to make a solely intellectual inquiry into a domain by appealing to the intellectual qualities of the technological concept itself, but to create empathy for the potential users in the envisioned future. Thus, we might consider the positive effects of animation-based learning for novices as generally valid for animation-based sketching as a whole, since the situation in sketching is always similar to the learning situation of novices who need to explore and predict aspects of a future state of reality. The main benefit here is the notion of sketches not as *presentations* of reality, but as *representations* of reality (Tversky 2002). The sketch adds new information to the here and now, and maybe even distorts it.

The principle of interactivity is transferable to the extent that it fits the aim of exploratory design, which is to enable the designer to iterate back and forth by interacting with the animation tools. Likewise, the interactivity of simple control mechanisms, for example, allows stakeholders in the design project to pace their 'reading' of the design deliverables and design insights in feedback-loops, as proposed by Buxton (2010).

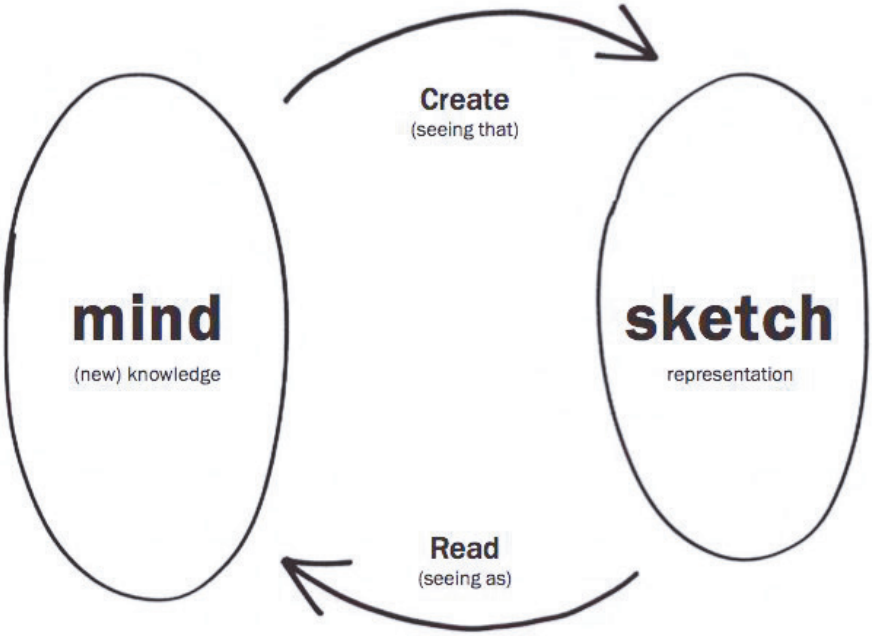


Figure 24: Buxton's simplified dialectic between externalising thoughts through sketching, and reflecting back on the expressed in reflective loops inspired by Schön (1983).

The principle of interactivity is thus an integrated aspect not just of 'reading' an animation-based sketch, but also of the sketching processes of animating the sketch itself. Thus one of the main differentiators between the insights from animation-based learning and animation-based sketching is that in a formal learning context, only the animated output itself matters: the aim is to create an understanding of the complexities of a phenomenon. In design sketching, by way of contrast, the processes of sketching are just as important as the finished output – if not more so. The processes are crucial because they enable reflection-in-action in the designer's exploration of the design problem. In animation-based sketching, the learning aim is not expressed in a final sketch intended to facilitate further reflection, feedback and critique, but rather in the sketching processes itself, reflecting the investigative and explorative function of sketching and enabled by interactivity in the digital production environment of animation-based sketching. We therefore have an evaluative criterion to apply in examining production environments in part III of the book.

To summarise, previous studies of the use of animation as a facilitative tool have been restricted to very specific use cases of learning and instructional material. Even though the insights and contributions from these cases can be criticised for not providing definitive answers about the general value of animation, the result do provide us with some indications that prove useful for understanding the facilitative role of animation-based sketching. What we might call *big picture thinking* involves envisioning the overall state of a future state of the world and uses temporal information regarding the non-idiomatic aspects about which static imagery cannot inform us, and here the results from the novice learning use cases may provide inspiration. The principles of attention-guidance, apprehension, congruence, and interactivity may all be applicable to animation-based sketching to some extent, as long as we bear in mind the duality between 'sketching' and 'the sketch': it is not only the end 'product' that is important in the design domain. If nothing else, the literature reviewed in this section and its critical comments show that many authors have noted that animation has a tremendous potential to facilitate visuospatial reasoning via temporal information. While animation may not promote formal learning in all instances, we argue that it constitutes a promising perspective on generating information which reduces uncertainty rather than complexity.

MOVING ON FROM THE FOUNDATIONS

We now have a foundational understanding of the three core concepts needed to address the definition and potential of animation-based sketching. We have discussed design sketching as the subject matter and core activity of both design thinking and design communication. Furthermore, we have discussed the limitations of traditional static sketching when confronted with the temporal dynamics of new non-idiomatic technologies, and how temporal sketching capacities might offer a way to address these issues. Finally, to address the potential of animation in facilitating the knowledge generating process of design, we have sought to acquire a nuanced and deep understanding of what animation is and of how it is different from live action video.

This marks the transition from the first part of this book to part II. We now change the scope from reviewing the foundational core concepts behind animation-based sketching and go on to seek a definition and core characterisation of the approach itself.

PART II: A DEFINITION

In this second part of the book, we will attempt to connect the foundational concepts to create an understanding of how animation, as apparent motion, can be used as a sketching approach to facilitate the reduction of uncertainty in non-idiomatic design situations. We start the section with a chapter reviewing previous attempts to understand animation within the domain of design sketching. These perspectives are used to propose animation-based sketching as a digital sketching approach with its own specific epistemological conditions for the generation of information. On this basis, animation-based sketching is defined as a way to emulate a digital system, by using animation to portray a proposed fictional future that is intended to become factual. This separates animation-based sketching from other approaches to animation outside the domain of entertainment and art, which we finally map into Ward's (2002) ontological map of animation studies as we introduced in chapter I.

Finally we extend our definition of animation-based sketching by exploring the archetypical features of animation-based sketches on the basis of a sampling of sketches.

CHAPTER 5
PRIOR APPROXIMATIONS

In this chapter we develop upon our review of animation, sketching, the challenge of non-idiomatic technologies, and the previous attempts in temporal sketching, by reviewing the previous approximations to apply animation techniques in design sketching. This lead us to establish how the role of animation has been experimented with in interaction design cases, but only to an extent of assessing individual techniques alone. The broader scope of animation, as an approach with multiple techniques, materials and genres is not addressed, and makes the existing cases intriguing, but with little reflection upon animation-based sketching as a way of doing design.

We end the chapter by arguing for the need to think of animation-based sketching in a broader scope as a tool agnostic approach - a set of principles for creating temporal sketches through a variety of tools, techniques and enabling technologies. Furthermore we propose that the unanswered questions from the previous approximations are in regard to the different ways animation can be utilised for sketching, the fidelity of animation required for sketching, as well as wether it is a viable approach for novices in animation to adopt in design.

EXPLORATIONS INTO ANIMATION IN THE DOMAIN OF SKETCHING

To some extent, as we have already stated , animation in sketching has previously been subjected to academic inquiry in a series of experiments that used animation techniques at different stages in the design process. The contributions touched upon in chapter 3 used animation interchangeably with video in ‘video sketching’ and ‘video prototyping’ (Mackay & Fayard 1999, Vertelney 1989, Bardram et al 2002, Tikkanen & Cabrera 2008). Augmenting traditional video with animated motion graphics is by far the most common way to include animation as part of sketching vocabulary, even though the animation techniques themselves are not examined or analysed in detail in the contributions but are discussed in the same terms as live action video. However, a few other contributions address the use of animation more directly, actually assessing the qualities that are unique to animation and their suitability for design processes.

An intriguing example is Jonas Löwgren's proposal to use motion graphic elements to create animated use cases that can gather feedback and explore the fuzzy front end of design ideas (Löwgren 2004). The created animated scenarios had a explanatory sketching intent a at late stage in the design process, when the stakeholders had to decide whether or not the idea to spend further resources. Löwgren's experiment sought to make the stakeholders reflect upon the sketch in a workshop, and avoid it being considered a persuasive sales pitch. Löwgren noted that the stakeholders' reception showed that the animated sketches were perceived as being clearly something else than animations made with marketing aims; they clearly communicated the technical details of the temporal interactions over time and between contexts.

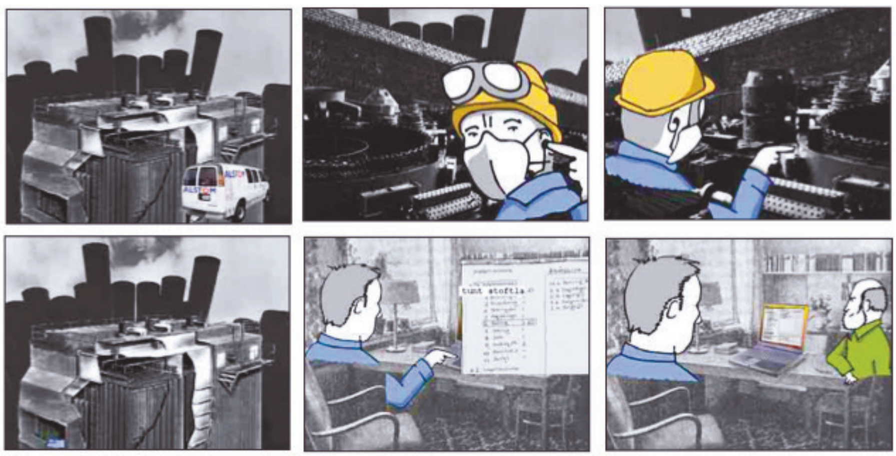


Figure 25: Stills from Löwgren's animated use sketch, expressing the use case of a voice controlled service system, enabling electricians to record and store their observations in the field. The sketch is made via keyframe animating graphical figures on top of still photographies via Macromedia Director.

However, Löwgren does acknowledge that that the animated representations tended to communicate and persuade to a larger extent than neutrally illustrate. This indicates a risk that they might be interpreted as rhetorical and persuasive, rather than as explorative ideas inviting further reflection. The viewer might tend to "lean back" and see the sketch as a whole and respond to to sketch itself, and not the proposed underlying idea - much like the problem Buxton (2010) and Ylirisky & Buur (2007) pointed to with the challenges with getting the right feedback on the Apple Knowledge Navigator. Löwgren also noted that it took a total of 25 hours to create the moving-image representation, which makes the approach less than ideal for rapid reflection-in-action during "conversation" with design problems. Löwgren's results indicate that in order for animation-based sketching approaches to work, we must seek to use the techniques in a format which allows fast and cheap completion and which emphasises the investigative and explorative functions of sketches, rather than focusing on their explanatory and persuasive functions. Finally Löwgren's account also serves to remind us that sketching is both a process of reflection-in-action and an output format or visual style. What his animated-use sketch shows is that something can obtain the visual style of a sketch without necessarily being the product of a reflective sketching process. This echoes Buxton#s cautionary note that *"Just because something looks like a sketch, it does not mean it is a sketch*" (Buxton 2010, 338). The rendering style of a sketch is not a guarantee that the information it generates is suitable to reduce uncertainty about the design possibilities.

Attempts to adopt a more reflective digital sketching approach are offered in the workshop accounts of Bonanni & Ishii (2009), Zarin et al (2012) and Fallman & Moussette (2011). Here, stop motion animation is applied in early explorations of interaction design and architectural processes. Bonanni and Ishii (2009) suggested stop motion animation as an approach to low-fidelity concept prototyping of tangible interfaces. They made several remarks about the technique's potential which are aligned with our definition of sketching as the generation of new information. For instance, they can explore and reveal various impacts of technologies that do not yet exist by showing the interactivity. Their conclusion however, isnot unlike Löwgren's: stop motion animation in sketching mainly involves the communicative function of sketching rather than the 'visual thinking' traditions of Goldschmidt (1991) and Schön & Wiggins (1992). While they judge that animation can provide an relatively easy way to explore interaction design ideas, before investing in building functional systems, they also primarily frame the idea as an aid for presenting ideas that have already been shaped and represented in other formats.

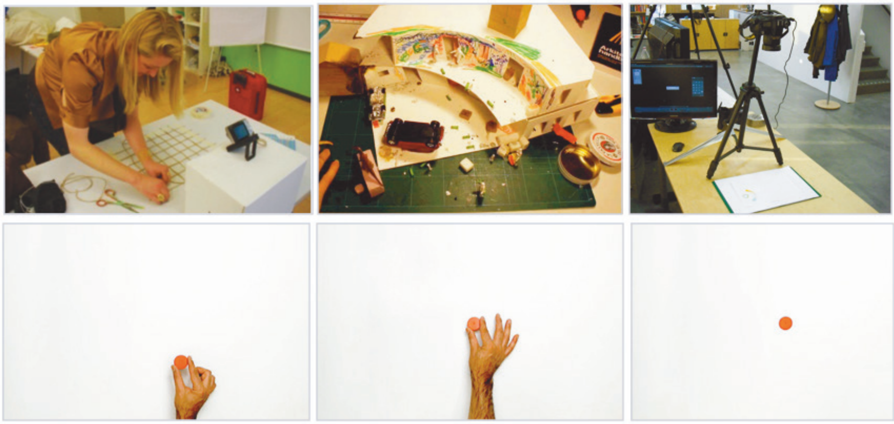


Figure 26: Stills from the studies by Bonanni & Ishii (top) and Fallmann & Mousette (bottom) showcasing how stop motion can be applied to explore early interaction design concepts.

Zarin et al (2012) and Fallman & Moussette (2011) oppose this view in their studies of the introduction of stop motion animation to interaction design students. They suggest that since stop motion animation are built frame by frame, it allows the designer to bypass the constraints of materials, physical properties and realities. The argue this makes it easier to think about ideas that change the conditions of space, time, and materiality, much as proposed by the eight digital genres of Pine & Korn's 'multiverse' (2009). This indicates that simplistic animation such as stop motion provides support for quite detailed explorations of dynamics aspect of interactive systems, which moves, flows, transitions and changes between different modes. The conclusion that can be drawn from their studies is that when it comes to working with and reflecting on processes, stop motion animation is useful for revealing and thinking about complex situations and consequences involving new technology, environments, and people. It does so in a way that requires less in terms of production environments and required competencies than more complex video prototyping. Fallman & Mousette (2011) even go so far as to ask whether we might regard stop motion as the pen & paper sketching of interaction design. In the later contribution, however, Zarin et al (2012) are less laudatory:they report that another set of students experienced more challenges and spent more time on successfully developing stop motion based sketches.

The results are interesting for the venture of extending upon animation-based sketching as a design approach, since it provided one of the first analytical perspectives on a specific way of using animation to generate information and thus reduce uncertainty in a design project. Furthermore, the conclusion that even the production of simple animation as stop motion might take a considerable amount of time to use for sketching, is also intriguing. It raises the question: is it possible to adapt stop motion and other animation approaches in a format in which the sketching time and sketching competencies have been sufficiently reduced to actually be ‘the pen & paper of interaction design’?

LESSON LEARNED:

Animation can be used in design sketching to either make something look like a sketch or to explore simple concepts and interactions.

Three areas have not yet been addressed in-depth:

1) The fidelity of animation-based sketches

2) The competencies required to make them

3) The time it takes to produce them.

When it comes to building upon previous contributions, these three questions imply some considerations regarding *how* animation-based sketches are made. These involve addressing animation approaches and techniques themselves, such as the use of fully animated use cases in Löwgren’s work, and the stop motion examples just covered. The *how* of animation-based sketching also involves production materials, especially the enabling technologies of animation. This includes an examination of the software that might be used to create and manipulate animation-based sketching. Here, a central question is whether we need dedicated software or off-the-shelf software tools.

Dedicated enabling technologies for using animation in explorative processes has been created previously. As early as 1969, Baecker presented Genesys (Baecker 1969), a system which could record changes in position, orientation and shape of virtual objects. In early 2000’s Adobe’s software packages popularised digital keyframing, in which two positions are designed manually, leaving it up to the system to interpolate between these two states (Wells 2006). Lately procedural approaches to animation has become popular ways of fusing the creation of apparent motion with algorithmic code, determining the animated behaviour over time (Martinez 2015).

In recent years, examples have been presented which adopt a sketching mindset. For instance, in the 'motion-by example technique' (Moscovich & Hughes 2003), where the user drags an object around the screen while it is being recorded by software. Similar approaches have been applied in a series of dedicated software demos such as 'K-Sketch' (Davis et al 2008), 'Sketch'n'Stretch' (Sohn & Choy 2012) and 'idAnimate' (Quevedo-Fernández & Martens 2012):

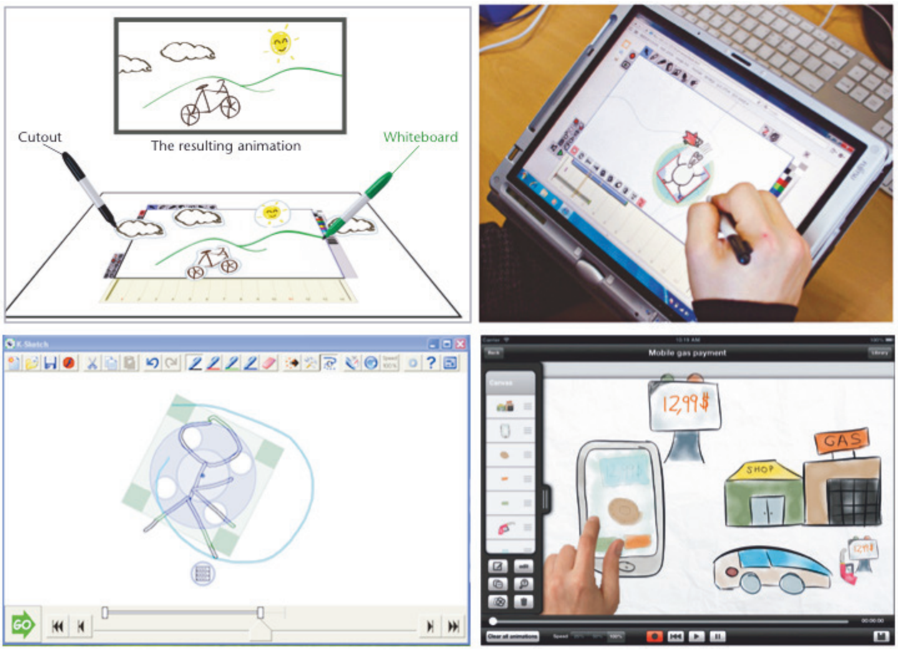


Figure 27: Stills from Stretch n' Sketch (top), K-Sketch (bottom left) and idAnimate (bottom right) - all special made production environments to the purpose of combining one specific animation technique with sketching.

In their studies, these authors develop different kinds of desktop or tablet software aimed at making it easier for designers to record motion in digital graphical productions, to convert cut out elements to digital animations, or to lower the threshold for creating 'keyframe'-based animation. All of these studies address the potential of temporal sketching compared to static design sketches. However, they do not address animation as a general approach; instead they concur with Ylirisky & Buur (2007) and Buxton (2010) that traditional animation and animation tools are not viable for sketching. Instead, their studies focus on the technical side of how animation is realised in their proposed software and on its potential to lower the participatory threshold when it comes to creating animations for design sketching. The three studies also criticise research in animation software for facilitating learning, communication and information visualization; they see it as too specific and as constraining the animator to a specific form. They propose that what sketching needs is a 'general purpose tool' (Sohn & Choy 2012, Quevedo-Fernández & Martens 2012).

All three studies are interesting and highly valuable contributions that attempt to address the *how* of applying animation within design sketching. They are particularly praiseworthy for they experimentation with lowering the threshold of competencies and with reducing the time demand on creating animation for sketching purposes. However, one might argue that they can all be subjected to the same 'specificity critique' they raise. One might also question whether they can really be characterised as 'general purpose' when each software demo only allows one type of animation technique (cut outs, keyframes or motion-by-example) and a pre-specified set of animation mediums (digitally drawn elements or pre-made graphical elements). Even though the purpose of the tools is non-specific and general, the tools themselves are also highly specific. Just not by topic, but by production. We would argue that to function as a general purpose sketching tool, an animation tool should be able to encompass different medium genres, production techniques and topics. Sometimes, an interaction design problem might require us to animate interface elements using the keyframe animation of graphics; at other times, we might need to show many interactions between humans, artifacts and environments by using stop motion via cut out elements. If the designer is limited to generating temporal information about the design problem without being able to explore different materials and techniques, the expressive capacity of the information will naturally be more limited.

The point is that while limiting animation to a small set of techniques or materials might lower the participatory threshold and make it more time efficient, there is a risk that it might also limit the material conversations (Schön 1992) so that they become too pragmatic, addressing *what* the specific material can express, and not what animation in general can express. The ambition of creating dedicated software to handle issues of fidelity, competencies and time consumption in animation is interesting and valuable, but it is nonetheless just one specific way of approaching animation as a sketching tool for design processes.

LESSON LEARNED:

Animation-based sketching should be seen in a broader scope as ***a tool agnostic approach***. Or more precisely, it should be seen as a set of principles for creating temporal sketches through a variety of tools, techniques and enabling technologies.

This brings us back to the fundamental question of *what* animation-based sketching is. To further develop our understanding of *how* animation can be applied in design sketching to reduce uncertainty about the design possibilities of non-idiomatic technologies, we need to build upon our now established foundational theories and establish a formal definition of animation-based sketching.

CHAPTER 6
ANIMATION AS DIGITAL SKETCHING

In this chapter, we discuss the basis for claiming that animation-based sketching is tool-agnostic and that it is also a digital sketching capacity. In doing so, we identify the links between digital animation and the epistemology it shares with that of digital programming.

In software, the designer can determine in advance the behavioral rules of the system. The same is true for digital animation, where the designer controls the arrangement of graphics and sets the positions which forms the creation of apparent motion. In this sense, the difference between *animation* and *programming* is blurred: we might say that the programmer animates and the animator programs when creating apparent motion in digital software.

We build upon this digital sketching notion in suggesting that animation-based sketching should be viewed as a digital emulator, digital software as simulators and static sketches as depiction. This forms the basis for describing how animation-based sketching relates to and differs from both static sketches and the digital systems the animation emulates. Thus this chapter establishes the last piece of the puzzle needed to define animation-based sketching.

ANIMATION - A DIGITAL SKETCHING CAPACITY

The next step towards defining animation-based sketching is to address it from a technological perspective. The examples covered in the literature review of previous contributions regarding animation-based sketching seem to have one common denominator: all are based on the use of digital software as an enabling technology to animate the sketch. Even though we might create elements and record their movement in physical form, we edit and essentially arrange the graphical positions using some instance of digital software. In principle, one could sketch with animation without using digital software; however, the great strength of digital software is the flux between data and program to handle data (Finneman 2005, Löwgren & Stolterman 2004). This allows the user to quickly and constantly iterate within the digital animation software without having to redraw or re-record the material. This is crucial to the design process, allowing reflective conversation with the material (Schön

1983) to take place as a fluent process of move-see-move experimentation with ways to create a fitting representation for the interactions. Without the iterative cycles, animation-based sketching could be described as purely a communication device for reflection-on-practice expressing reflections that have already been made.

'Reflection-in-action' happens when designing the graphical positions (graphism) using either physical or digital artifacts and recording them in pictures or on film, together with live action elements. However, as soon as the designer begins to explore how to manipulate the different elements into combinations, how to create apparent motion, and how to use the mixture in a full exploration of the non-idiomatic design context, the designer undertakes a mixture of reflection-in-action and reflection-on-action. In using various digital tools and software to edit the bits and pieces together, designers temporally and visually express the reflections made previously in creating, deciding, recording and manipulating the elements. This creates a principle of *non-continuous production* in the animation-based sketching process, where in most cases the production of the image occurs in a different time from it's playback as apparent motion. In terms of Schön's modes of reflection, this means that animation-based sketching is epistemologically different from traditional static sketching since it breaks the sketching process into two stages - *capturing* and *editing*.

Static sketching adheres to the tradition that we previously labeled 'visual thinking', in which the designer's reflection-in-action enables the designer to see more in the created sketch than was put into making the sketch originally. This is also the case when capturing material for animation-based sketching; the designer decides upon what and how much to move an object in the animation process. This decision making happens in a dialogue with the situation (Schön & Wiggins 1992), and thus also creates a potentially different variant of the idea than might have been thought of before.. The designer reflects on the choices made in capturing materials in order to plan how to manipulate the materials in the given software to create the desired apparent motion, and this amounts to a reflection-on-action about a previous process. However, in manipulating the material in the software the designer also obtains temporal information which did not exist prior to the editing situation. Reflection-in-action begins again as the designer listens to what we might label *'the temporal backtalk'* of the animation(s) created in the software. This backtalk is what enables the designer (or animator for that matter) to obtain more information from creating the animated sketch than existed before the creation of the sketch.

It is in this overlap between reflection-in and reflection-on that animation-based sketching differs from the traditional hand-drawn sketching process, in which reflection-in-action happens during the capture of the sketch, and from reflection-on-action, which typically first occurs during communication of the sketch to others, for instance in a critique session (Buxton 2010, Schön & Wiggins 1992). The use of digital tools in creating, editing and manipulating materials to create animation enables this overlap between reflection-in-action and reflection-on-action. Thus, through its ability to iterate dynamically, the digital medium plays a crucial role in enabling temporal backtalk. This ties animation-based sketching to the digital realm, as was already implicit in the review of the previous research. Thus, digital materiality makes animation an approach to sketch with, and not just a way to create independent animated content. Consequently, a more precise way to talk about animation-based sketching would actually involve using the term *digital* animation-based sketches. The overlap between capturing and editing is thus also a transition concerned with *digitising* material into a format that is ready for digital editing, by first *sampling* and then *quantisation*:

> *"Digitisation consists of two steps: sampling and quantisation. First, data is sampled, most often at regular intervals, such as the grid of pixels used to represent a digital image. The frequency of sampling is referred to as resolution. Sampling turns continuous data into discrete data, that is, data occurring in distinct units ... Second, each sample is quantified, that is, it is assigned a numerical value drawn from a defined range (such as 0–255 in the case of an 8-bit greyscale image)."*
>
> (Manovich 2001 p. 28)

When capturing material in the real world and later editing and manipulating it, digital sampling shares the discontinuity discussed above. However Lev Manovich points out that because of quantisation and coding, digital samples can be programmed, unlike analogue data (Manovich 2001, 51). From this programmable character derives a paradox for our definition of animation: if the data we capture can be autonomously altered by programmed algorithms, does the designer/animator animate or is it the software? Omar Martines (2015) discusses this issue in his paper about the issues involved in describing digital animation, and among other things he touches upon the role of *agency* in digital animation software:

> *"Animation can be characterised according to its two general types of sources, where agency referees to the deliberate determination of illusory movement by a agent, while causality refers to cause and effect processes, whether accidental or systemic (from e.g. computer automatisation)"*
>
> Martinez (2015)

The illusion of motion - or what we label apparent motion - is agential to the extent that the designer either arranges the material between a set of stages to create the motion or pre-determines the parameters which the digital software will use to simulate changing positions. In other words, the digital software is a simulator of motion. Martines refers to Gonzalo Frasca's notion of the designers of digital animation as 'simiauthors' (Frasca in Wolf & Perron 2003, 227), who set the rules that simulate motion or change in visual information presented by the system. Frasca explains that *"to simulate is to model a (source) system through a different system which maintains (for somebody) some of the behaviors of the original system"* (Frasca in Wolf & Perron 2003, 223), and thus simiauthors creates the rules of the simulated model of reality. Thus, software allows the designer to determine in advance the rule of how positions of graphical components creates apparent motion over time.

LESSON LEARNED:

The difference between ***animation*** and ***programming*** is blurred in the creation of apparent motion in digital software: we might say that the programmer animates and the animator programs.

Thus, designers using digital software are also as animators to the extent that they may determine the creating of motion. They do so through the computer code or through the same logic by changing variables in the software. Whether or not the software has an interface as the front-end for manipulating these variables, using digital software to edit and create the animation-based sketch is based on an epistemology which has a lot in common with that of the programmer. However, the manipulation of variables, which in turn pre-determines the creation of apparent motion, actually continues what Norman McLaren initially described as the '*manipulation of the differences between successive frames*' which constitutes the animator's praxis (Sifianos, 1995: 66). As McLaren provides the basis for our definition of animation as ***the process of deciding and manipulating the differences between a set of graphical positions, with enough difference to produce a sequential illusion of apparent motion***, the programming-like epistemology of digital animation actually supports this broad view of animation rather than conflicting with it. Thus, animation-based sketching as a tool-agnostic but digitally enabled approach does not conflict with either analogue or digital means of defining animation. It does, however, raise an important ontological question. If digital animation is described in Frasca's terms as aligned with 'simulation', is that also the defining characteristic of animation-based sketching?

THE COMPUTER AS A SIMULATIVE MEDIUM

In 1984, computer scientist Alan Kay described digital technology as:

> *" A medium that can dynamically simulate the details of any other medium, including media that cannot exist physically. It is not a tool, although it can act like many tools. The computer is the first metamedium, and as such it has degrees of freedom for representation and expression never before encountered and as yet barely investigated."*
>
> Kay, 1984

Kay's description is related to the general architecture of computer systems, which are described (Rosenstand 2002, Rasmussen & Barret in Morán et al 1995) as 'simulators'. Like Frasca's notion of the concept, a simulator in computer science consists of a model of a bounded part of reality. This model can be influenced from the outside (input), and it will react (output) in a similar way the represented is expected to react in reality (Rosenstand, 2002). This means that the model is dynamic and can change on the basis of either external or internal dynamics. Rasmussen and Barret formally describe the simulator as the core aspect of any digital systems as

> *"a simulator is an emergence engine. It is a representational mechanism that is distinguished by its capacity to generate relations that are not explicitly encoded."*
>
> Rasmussen et al., 1995

The formal description of the computer as a simulator works for any digital system, including systems with no direct user influence. With the advent of human-computer-interaction (HCI), researcher Brenda Laurel coined the metaphorical term *computers as theatres* to describe the way in which digital simulators created the human-computer experience (Laurel 1993). To Laurel, the bounded model of reality was a *'distorted model of reality'* and was:

> *"about creating imaginary worlds that have a special relationship to reality—worlds in which we can extend, amplify, and enrich our own capacities to think, feel, and act."*
>
> Laurel, 1993,

Laurel's description of the representational power of digital computing can be seen as a perspective on the multiverse model of digital genres proposed by Pine & Korn (2011). We can view these genres as possible simulative domains, which the computer can extend, amplify and enrich in interaction with the user. In HCI, the input and output to and from a simulator is the based on *interactivity*, where interactivity is defined as "… *a measure of a media's potential ability to let the user exert an influence on the content and/or the form of the mediated communication"* (Jensen, 2008). This is mediated through the interface, which connects the computer system to its surroundings through different interaction modalities.

The facilities that can be used by the surroundings through the interface to influence the dynamic model (input) and the facilities that the model can use to update the interface (output) correspond to what computer science typically labels *'functions'* (Mathiassen et al., 2000). From an output perspective, the interface represents the state of the model, and from an input perspective, the state of the model is a function of the interactions performed by the user.

Thus, digital systems understood simulators consist of the synthesis between interface, functions, and model:

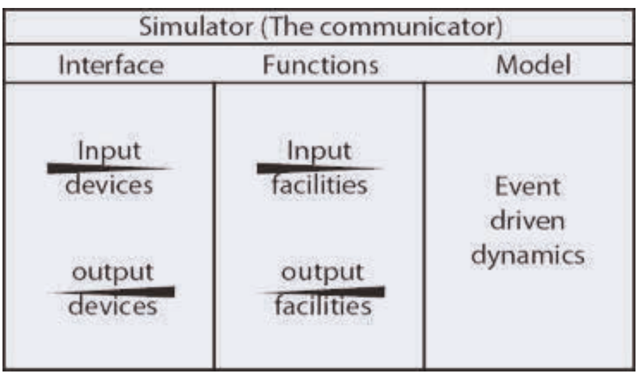


Figure 28: The simulator, consisting of a bounded model of reality, which is manipulated through a series of input and output functions, mediated by an interface. Depicted from Rosenstand (2002).

This shows why the digital medium has often been described in terms of being *informational* and *able to represent all other mediums as content* (Finneman 2005), or more simply as *"...the material without qualities"* (Löwgren & Stolterman 2004). The bounded model of reality can be configured to model any given part of a factual or made up reality, with a given functionality mediated by a user interface.

This takes us back to the question of the role played by animation in exploring specific ways of simulating bounded models of reality in digital systems.

Between simulation and depiction lies emulation

Earlier, we introduced Gonzalo Frasca's notion of the designers of digital animation as 'simiauthors' (Frasca in Wolf & Perron 2003), who set the rules that simulate motion or change in the visual information presented by the system. Frasca's notion of animation as the simulation of motion works well to describe what happens when we use a digital production environment to create apparent motion. However, the situation becomes more complex when we introduce the notion of the computer as a simulator itself, and when we aim to use animation as a way to sketch a future configuration of such simulators. The issue is that we use a digital simulator (the animation production environment) to simulate another simulator itself (a given digital system). However, we essentially do this by creating a temporal sequence of information which does not adhere to the same simulative qualities as the digital simulator - the animation does not maintain all the qualities of the modelled system. This is most obvious in the lack of input and output modalities in the interface of the animation-based sketch - the user cannot (at least per se) interact with or change the dynamics of the modelled system. The user can only observe its dynamic model of reality.

This places animation in an ontologically different position than both traditional pen and paper sketching and interactive prototypes when it comes to exploring a digital system.

Traditional static sketches enable the *depiction* of a bounded model of a reality, but they do not represent dynamics or interactions - unless they leverage established idioms for the viewer to fill in the temporal blanks on the paper. Thus, a static sketch is only able to depict the bounded model of reality in single states, without input, without output and without the dynamics between the elements of the simulator.

On the other hand, prototypes can provide a dynamic model of reality together with functionality mediated by interactive input and output, thus showing the complete simulation of the interactive system. A prototype can be defined as "*a limited representation of a design that allows users to interact with it and to explore its suitability*" (Preece et al 2011). However, this limited representation involves all aspects of the digital simulator, and the designers' decisions thus concern whether to reduce complexity involving the breadth of different features or involving the details in depth of a specific function. Usability pioneer Jacob Nielsen terms this the division between the *'Horizontal prototypes'* and *'Vertical Prototypes'* of the full system (Nielsen 1993):

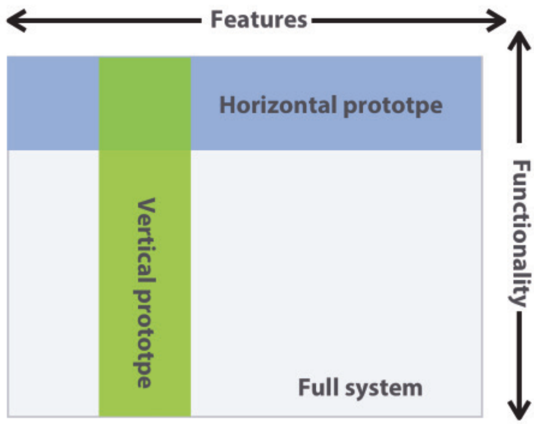


Figure 29: A visualisation of Nielsen's (1993) concept of either prototyping a limited set features vertically with much detail, or prototyping a wide set of features, but with limited functionality in each feature.

Whether prototyping vertically or horizontally, the essential feature of prototypes is that they express the model, the functions and the interface of the simulator. This fits with Buxton's notion of prototypes as a means to 'getting the design right' and our definition of prototypes as a way of reducing the complexity of information (concept ideas and variations). As soon as we have a prototype, as limited a representation as it may be, we have a unified set of information about how the digital simulator *'might be'*, and thus we need a testable expression in order to move the design process forward. But making a prototype outside established design patterns, conventions and idioms of interactions can make the prototyping process lengthy and costly (Buxton 2010). Even though methods have been proposed to *sketch in code* (Lindell, 2012 & 2012b, Forséna et al 2010), they also tend to narrow down the focus, converging the design process rather than maintaining the divergent sketching mindset of creating design alternatives. Furthermore, even when sketching in code, the time spent creating the sketch is still far longer than the time required for static sketching. This underscores the role of sketching seen from a more design logistic viewpoint - making it affordable to create and compare alternative design proposals throughout the design process (Buxton 2010).

We argue that situated between *depiction* and *prototypical simulation* as modes of representation, animation provides a third distinct mode of representation. By manipulating the position over time of different graphical elements to provide a model of reality, and by generating temporal information, an animation can illustrate the dynamics of the interactive system, even though the input and output are not realised as a full simulation. This means that animation-based sketching is ontologically different from both static sketches, which depict, and prototypes, which simulate. On the other hand, we drew on Frasca and Omar to establish that the animation process itself is a process of simulation. This makes animation-based sketching complex, in that we simulate motion and change in the inanimate in general. But when it comes to using motion and change to explore a proposed digital system, we simulate something which is already a simulation, and thus we are actually not simulating the digital system: we are *emulating the digital simulator!*

Emulation is best described as *'the imitation of a certain computer program on another platform or program'* (van der Hoeven et al 2007). An emulator is by itself a designed application that creates an extra layer between an existing computer platform (a host platform) and the platform to be reproduced (the target platform). In the context of emulating a not-yet existing technology with animation, this setup could be modelled like this:

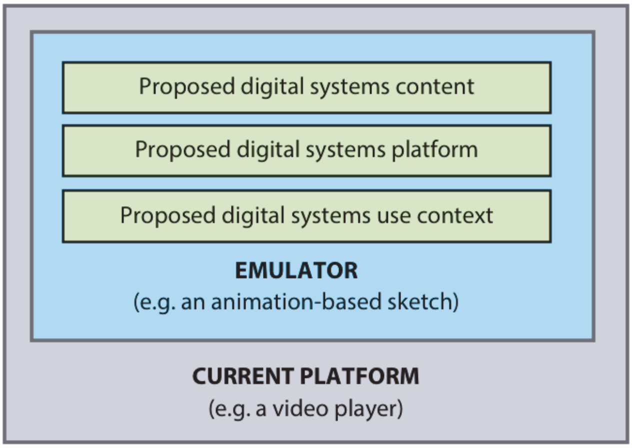


Figure 30: Our proposal for viewing animation-based sketches as an emulator - being able to emulate the digital simulator as well as its context on another platform - like e.g. a video player (authors own model).

The term emulation is specified as the complete imitation of a machine, while simulation refers to computer simulation, which involves the computation of a bounded model of reality with input and output (Pugh 1995, 274)

Even though the term *emulation* is typically applied in computer science with reference to compatibility insurance, to digital preservation or to hardware development platforms (van der Hoeven 2007 ; Magnusson 2004), we argue that animation-based sketching is yet another instance of emulation. When we employ digital animation to sketch aspects of a proposed technology (software as well as hardware) while using a playback medium to express the sketch, we are in essence using animation as the *extra layer* between the playback medium and the proposed future technology. In doing so, however, we do not represent the fully realised system, but only a scripted sequence of the system - a scenario in which the dynamics are set, thus leaving out the input and output functions of the simulator. Turning back to Jacob Nielsen's notion of vertical and horizontal prototyping, we might say that the emulation of a scripted sequence of the full proposed system is to be seen as one specific instance of multiple different ideas of possible digital systems *(figure 31)*.

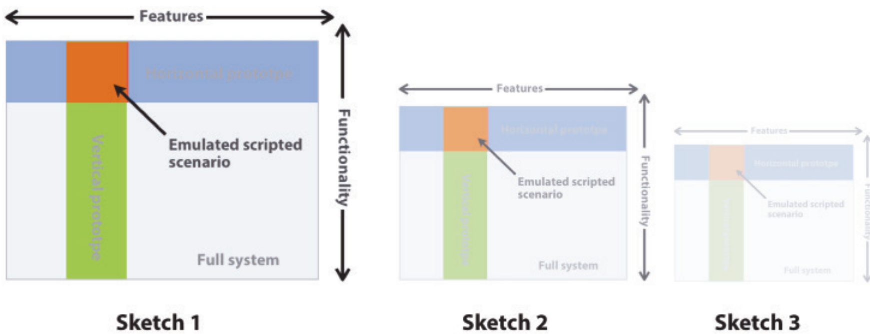


Figure 31: In the notion of Nielsen's model, an emulation of a simulator would be a limited representation of features and functionality, like when an animation-based sketch would present a scripted sequence of the proposed simulator. Each sketch could represent different overlaps of feature and functionality, expressing either multiple concepts of the simulator, or different aspects of the same (authors own model).

This demonstrates the fit between emulation and sketching. By emulating small aspects of the fully realised system, even if it is limited in its fidelity regarding the expressed features and functionality, animation-based sketching generates information about different possibilities in the design space, rather than prototyping the breath or depth of a defined system.

Prototypes, static sketches and temporal sketches such as animation-based sketches thus make up a typology of the representations of a digital system:

THE SIMULATOR *(e.g. a functional prototype)*
A **DYNAMIC MODEL** OF REALITY (FACT & FICTION)
WHICH CAN BE APPROCHED THROUGH **INPUT & OUTPUT**

DEPICTING THE SIMULATED *(e.g. a pen & paper sketch)*
A DYNAMIC **MODEL** OF REALITY (FACT & FICTION)
WHICH CAN BE APPROCHED THROUGH **INPUT & OUTPUT**

EMULATING THE SIMULATOR *(e.g. an animation-based sketch)*
A **DYNAMIC MODEL** OF REALITY (FACT & FICTION)
WHICH CAN BE APPROCHED THROUGH **INPUT & OUTPUT**

Figure 32: A functional prototype represents the full simulator's representation of a dynamic model of reality, which can be approached through input and output. A static sketch on the other hand can only depict the simulated model of reality, but not show its dynamics or be manipulated. Animation-based sketches, while still not able to manipulate the model by input and output, can represent the dynamics of the model, thus generating more information about the simulated than depiction (authors own model).

Thus, animation-based sketching involves the emulation of a sequence inside a proposed digital system, whereas non-temporal sketching enables depiction, and prototypes enable full simulation[1]. We have now isolated not only how sketching and prototyping in general differ (uncertainty vs. complexity), but also how a temporal sketching approach such as animation is different from both static sketches, and prototypes. This provides us with one of the final building blocks needed to describe animation-based sketching as a specific design approach in exploring interaction design and user experience in non-idiomatic design situations.

A final question remains to be answered: how should this way of using animation to emulate the digital simulator be understood in comparison to the other uses of animation inside and outside the design domain which were reviewed earlier?

[1] The idea of animation-based sketching as a emulative genre of representing the digital simulator was coined in collaboration with my good colleague Claus Rosenstand in Vistisen & Rosenstand (2016)

CHAPTER 7
DEFINING ANIMATION-BASED SKETCHING

This chapter finally proposes a definition of animation-based sketching as a design approach. We initiate the chapter by reviewing the use of 'functional animation' as the catch-all definition for the use of animation outside the domain of entertainment and art. We explain why this definition is problematic and show that animation-based sketching, as opposed to the functional genres, has as much in common with the creation of fiction as it has to do with the factual genres of animation.

ANIMATION-BASED SKETCHING IS DEFINED AS:

Using animation to portray a fictional reality that is intended to become factual

We conclude this chapter by placing animation-based sketching in the ontological map of animation proposed by Paul Ward (2002). We place animation-based sketching along the tradition of Art & Design studies, with sketching emerging as yet another epicenter. It is not defined as functional animation, but rather overlaps with the characteristics of both Art & Design and the notions of functional animation.

IS ANIMATION-BASED SKETCHING FUNCTIONAL ANIMATION?

For our final approximation to the definition of animation-based sketching, we must go back to the very beginning of our work and to the ambition of the Animation Hub Network to understand the concept of 'functional animation'. We will seek to discuss whether it makes sense to define animation-based sketching as a sub-type of functional animation, or whether its definition needs its own ontological place in animation studies.

Functional animation is a problematic concept since it essentially has no scientifically based definition. Furthermore, since its definition is so broad and takes cues from a multitude of other ways of describing animation, it has been influenced by various definitions proposed by educators, practitioners and researchers. The main problem is that the term is used to describe widely different concepts of animation, and not only the use of animation within other domains than entertainment and art. To the best of our knowledge at least three concepts exist in the current discourses, which we will argue contradict each other: *as part of interfaces*, *as factual information*, or as a *way of producing animation.*

As part of the interface

One use of the concept stems from the UX practitioner publishers' 'Smashing Magazine", which has featured functional animation as "*subtle animation that we embed in a user interface design as part of our process [...] functional animation has a clear logical purpose*" (Daliot 2015). This definition corresponds to earlier research contributions by Baecker & Small (in Laurel 1990) addressing animation in digital interface design. They describe eight uses of animating '*functions*' in the interface of products:

Animation	**Function**
as Information	*What is this?*
as Transition	*From where, to where?*
as Choice	*What can I do now?*
as Demonstration	*What can I do with this?*
as Explanation	*How do I do this?*
as Feedback	*What is happening?*
as History	*What have I done?*
as Guidance	*What should I do now?*

Baecker & Small 1990

While Baecker and Small do not use the term 'functional animation', their use of animation to portray functions in the interface of digital system is closely aligned with the logical purpose proposed by Smashing Magazine. However, one could ask whether the qualities of animation also affect the emotional character of the interface, just as different variants of motion affect the appearance of an animated entity. In this sense, functional animation is a way of using animation to support interaction through motion. It can add a sense of causality, pacing, rhythm and character to a web-site, for example.

In line with this, Chang & Ungar (1993) published an inspiring study of how different user interface elements utilise Disney animation principles such as squash and stretch, anticipation and follow through (Thomas & Johnston 1981) to make the computer system easier to use.

The important part here is that this application of animation contrary both traditional animation and other ways of using animation does not see animation as an independent expression, but as a functional component in a design.

Figure 33: Examples of functional animation understood as components in interface design. The 'genie effect' of stretching the windows on Mac OSX when minimising (left), and animating browsing through multiple screen modes on iOS (right).

This notion of animation is an intriguing concept that has become increasingly relevant with the advent of multi-touch interfaces and pervasive computing devices. With the non-idiomatic interactions involved, animation might help users understand the conceptual model of interaction with such technologies. Additionally, as part of the Animation Hub Network, another Ph.D research project was initiated to explore this further (en.animationhub.dk), although no results have yet been published. A working definition of this type of functional animation is *the use of animation as a design component to support interface design through motion inspired by both reality and fiction.*

As a factual information

The use of animation in formal learning and instructional contexts was discussed at great length in part I, and this specific way of using animation is also within the scope of the Animation Hub Network's label 'functional animation' (Thorning 2014). Baecker & Small speak of the *animation of process* as revealing or explaining complex processes or phenomena - in their case, primary algorithms and program code. However, the use of animation to convey information about a factual phenomenon is not necessary constrained to learning or instructional materials alone. Flight routes or animations of medical procedure to communicate with patients (figure 34) are instances of visualisations of dynamic information, and variants of what we would label *functional animation as factual information*.

Figure 34: Functional animation understood as factual information communicated through animation, like illustrating flight routes (left) and the function of a knee prosthesis (right).

According to the Animation Hub Network notion, this functional aspect af animation is the degree animation is used to portray aspects about factual reality - the here and now, or as in formal learning to predict the outcome of phenomenons affect in a context. The network do not relate to the fictive domains of entertainment or art, or to the abductive sensemaking of 'what if' scenarios in design thinking. However, the portrayed reality in this type of functional animation is not necessarily a neutral or objective portrayal. As we have seen before, animation can never really be objective, since it is a visual expressive capacity based on the contingent decision making of the designer/ animator. Consequently, even factual information presented via animation will be based on a certain perspective, leaving something in and something out of the expression. Animated propaganda has existed for nearly as long as the animated film (e.g Nysten 2015), and an animated visualisation of scientific phenomena will also be based on the choice of which details to include, which established paradigm to support, and so on. Thus, functional animation as information is to use animation to portray facts about reality - with a higher or lower degree of objectivity.

As a way of programming animation

Finally, the label 'functional animation' has been used in computer generated effects (CGI) and computer graphics research as a term for the adoption of principles from 'functional programming' in the domain of computer animation (Elliott & Hudak 1997, Arya 1986, Elliott 1998). This field sees functional animation as a high level programming vocabulary that can describe an animated model while omitting details of presentation (Elliot 1998). This approach to animation is a sub-form of so-called functional programming language (Bird & Wadler 1988), making the animation models reusable and composable for integration in interactive applications.

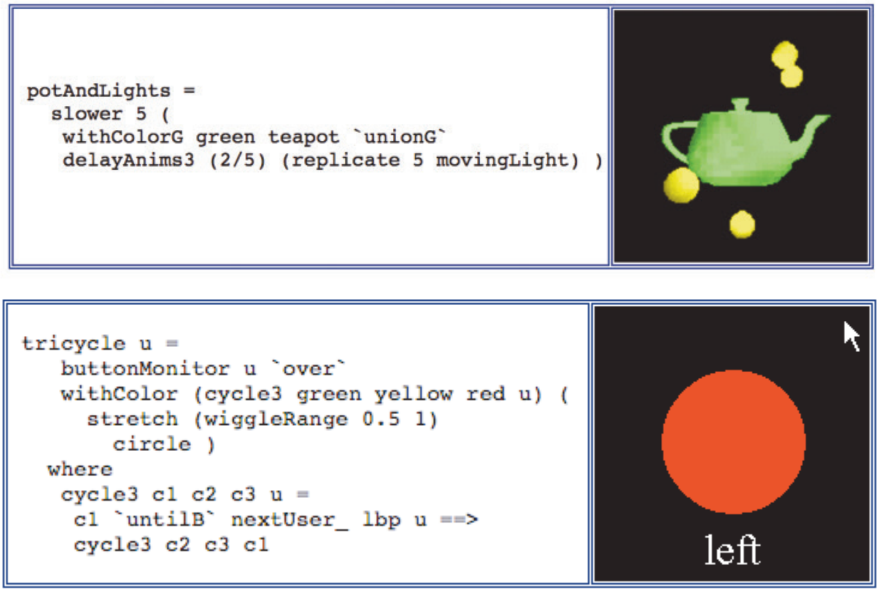


Figure 35: Functional animation understood as functional programming, where animated behaviour can be formulated through computer code to act according to different variables.

This is a completely different way of looking at animation, since its concern is not the *external qualities* of animation as a expressive capacity, but the optimization of the *internal aspects* of creating animations as a computer science craft. This concept is not part of the very broad definition of the term proposed by the Animation Hub Network. That the concept already existed and has so few ontological links to the other two descriptions of functional animation leads us to view this perspective as an anomaly, albeit it is because of a loose conceptualisation by the Animation Hub Network. To brand a concept from an already existing and radically different perspective on the animation domain as the common dominator for a new branch of animation is rather unfortunate; nonetheless, it is the foundation that we will use in our further efforts to position animation-based sketching.

A taxonomy of functional aspects in animation

Our short review has indicated that the Animation Hub Network's concept 'functional animation' is problematic due to its overlap with a concept from the domain of functional programming. It is also evident that we need a clearer taxonomy of *how* the different variants of functional animation use animation, and what the *aim* of each use is. This is also grounded upon how these uses of animation differ from what is labeled 'traditional animation' within entertainment and art.

DEFINING FUNCTIONAL ANIMATION:

We propose the following categorisation of functional animation types:

Traditional entertainment & art
Using animation to portray a fictional reality with the aim of creating an experience

Functional animation - Factual information
Using animation to portray facts about reality with a high or low degree of objectivity

Functional animation - Design Component
Using animation as a design component to support interface design through motion inspired by both reality and fiction.

Animation-based sketching might also be described as a way of using animation outside the domain of traditional entertainment and art. However, as was discussed earlier, it is not described fully in terms of learning, instructions or any other factual portrayal of information - be it subjective or objective. Moreover, while an animation-based sketch might explore a potential use of technology through animating aspects of its user interface and interaction, it is not itself the design component, but rather the vehicle in which we might use the functional animation genre of design components under given circumstances.

A DEFINITION OF ANIMATION-BASED SKETCHING

As an antidote to intertwinement with the troublesome definitions of functional animation, we have proposed above that animation-based sketching actually takes many of its essential qualities from the historical development of animation as a communicative genre. This correlates with the definition of design sketching as creating new information about the world so we can explore it and reflect upon it. Thus, animation-based sketching might be labeled as 'functional' to the extent that it uses the principles, traditions and methods of animation outside the domain of entertainment and art. However, due to the ambiguity of the origins and uses of functional animation as a term, we hesitate to use this label to refer to animation-based sketching. Instead, we argue that animation-based sketching is better described as 'developmental animation', without orthodox adherence to the aim of creating motion that is as realistic as possible and without being fixed on purely abstract uses of motion graphics to evoke emotions.

Animation-based sketching uses the qualities of animation to speculate about the future, filling the idiomatic gap of temporal information in dynamic design cases with few established patterns or conventions – or none at all. The important difference from other uses of developmental animation in entertainment and arts is that even though the sketch portrays a fictional reality, it does so with the clear aim that it might become real. The idea explored in an animation-based sketch is thus 'diegetic'; in other words, it is a product whose functions and implementation are true within the ontological boundaries of the narrative of which it is a part (Kirby 2010). This is an important notion, and it further relates to the poetic theory of 'possible worlds' (Ryan 1991, Dolezel 1998, Pavel 1975), which states that fictions can be understood on the basis of how easy or difficult they are to *access* from our real world. Accessibility can be understood as basic ontological laws in possible world that either enable or inhibit behaviour, and which are familiar to, and not in violation of reality.

In this regard, animation-based sketching differs from animation in entertainment and the arts by concerning itself only with possible worlds - scenarios in which the explored non-idiomatic technology would be able to leave its diegetic state and become part of factual reality. This provides us with the last element needed to establish a working definition of animation-based sketching:

ANIMATION-BASED SKETCHING IS DEFINED AS:

Using animation to portray a fictional reality that is intended to become factual

Animation-based sketching uses the process of deciding about and manipulating the differences between a set of graphical positions, with enough difference to produce a sequential illusion of apparent motion, and it explores a design space in the dialectic between framing the problem and formulating a possible solution. Furthermore, it uses animation-based sketches as the outcome of the animation-based sketching process to explain and persuade about the idea, to varying degrees that help others to obtain a visceral, intellectual and emotional understanding of a concept. Animation-based sketches thus provides shared points of reference which can act as frame of reference for other ideas, thus enabling further reflection.

However, our definition also entails that the sketches are only means to and end, and never the end goal itself. An animation-based sketch portrays a fictional reality, not for the sake of the experiential values in the fiction itself, but to facilitate the decision as to whether it should become real or not. It reduces uncertainty about the preferred state of the design space by generating information about the temporality and dynamics of a given idea. When the idea is a digital system, for instance in an exploration of the potential interaction designs and user experiences of a non-idiomatic technology, the animation-based sketch serves as an emulator of the digital simulator. As a design approach, animation-based sketching might best be described as a meta-medium which can portray other mediums in context and in use, providing temporal feedback about dynamics outside established design idioms.

The ontological fit for animation-based sketching

We now have a definition of animation-based sketching that is independent of the tools, mediums and genres of animation used and which is not tied solely to the sketching of digital systems. However, we have also defined the specific instance in which animation-based sketching is applied as a digital sketching approach to emulate a digital simulator, and we have discussed how this differs from static sketching and prototyping.

We now turn back to Paul Ward's ontological mapping (2012) and can place functional animation along the path of Art & Design studies. Here, design sketching emerges as yet another epi-center. It is not defined as functional animation, but rather overlaps with the characteristics of both Art & Design and functional animation from the perspective of using animation outside the domain of entertainment and art (figure 36).

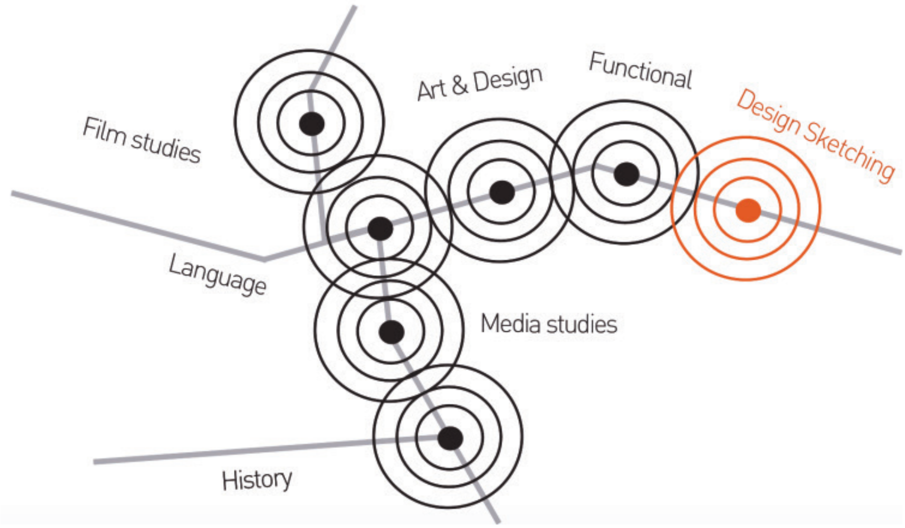


Figure 36: Separating the use of animation in design sketching from the topic of functional animation, we can now map two new epi-centers in Ward's model, along the fault line of Art & Design, with design sketching having overlaps with, but not bein equal to that of functional animation.

While we have seen that animation-based sketching takes many of its cues from discussions of animation in media and film studies, we argue that these are secondary features compared to the those of animation in art & design studies. The foundational ontological aspect of animation-based sketching is that it is animation used in the constructive activity of design: deciding and manipulating graphical positions to create the illusion of apparent motion with the aim of exploring possible futures states of the world.

CHAPTER 8
ANATOMY OF ANIMATION-BASED SKETCHES

To further describe the ontological aspects of animation-based sketching, we now explore the archetypical features of an animation-based sketch In doing so, the chapter presents five archetypical perspectives of animation-based sketches, as well as six archetypical narrative discourses:

PERSPECTIVE	DISCOURSE	INTENT	FIDELITY
Isolated interface & artifact interaction	Natural	Investigative	High Visual
Use scenario - present	Documentary	Explorative	Low visual
Use scenario - positive	Instructional	Explanatory	
Use scenario - negative	Comedic	Persuasive	High Temporal
Systemic view	Dramatic		Low Temporal

These archetypical features are realised through the use of either high or low visual and temporal fidelities, which often exist in a mix in animation-based sketches.

THE PERSPECTIVES OF ANIMATION-BASED SKETCHES

The identification of one specific description of what constitutes an animation-based sketch might be rather difficult. Despite being used in many variations in various interactions and user experience design projects, there are common traits shared by animation-based sketches. We have gathered a substantial number of sketches during the research project behind this book, and certain patterns seem to emerge among the variety of techniques, materials, styles, and intents of the sketches.

The first task is to describe the macro level of animation-based sketches. We have already established that animation-based sketches can emulate a proposed digital system, and in doing so, they generate information to reduce uncertainty about the design possibilities and thus also serve to frame the design setting.

After examining animation-based sketches - both from our own design processes, from the workshops we have facilitated, the examples found the previously reviewed contributions, we have derived five *perspectives* animation-based sketches has been observed to take.

- *Isolated interface and artifact interactions*
- *Present User scenarios*
- *Future user scenarios with a positive framing*
- *Future User scenarios with a negative framing*
- *Systems perspective*

Below, we will provide a short exemplification of each perspective.

Isolated Interface- or artifact interactions

This perspective uses animation to make the interface and/or interaction modalities of a proposed technology come to life and to provide temporal information about the input and output in the system. These sketches do not refer to of the user the context or the user(s) themselves, or else they only hint at them. While they show 'use over time' they are limited to only showing the dynamics of the technology itself, and not the dynamics of the interaction between user, context and technology. This perspective of sketching encompasses graphical, industrial and interaction design, which Buchanan (2001) argues are the first three orders of design, all being concerned with the artefacts and their immediate interplay with the user.

Figure 37: The sketch explores an idea of specialised smartphone to be used at hospitals and care facilities, in which animation is used to explore how one nurse would be able to notify other nurses in close proximity about a critical situation. See the sketch at http://goo.gl/i5tfLW.

We often see these sketches when the designer needs information about the fine grained details of the interaction with a system, for example when there is a need to generate information about different ways in which a system can represent information to the user. This type of animation-based sketch has a lot in common with instructional videos that show how to use a specific system, but with the clear difference that here we are sketching not-yet-existing interactions, whereas instructional videos convey instructions about existing interactions.

Present user Scenarios

These sketches are not really sketches in the sense of generating information to reduce the uncertainty about design possibilities, since they do not sketch any new design ideas. Instead, the they use animation instead of video to illustrate the current context of the user. Sometimes this choice is made as the faster and more practical approach, but it may also be used to realise what Scott McCloud labels 'amplification through simplification' (McCloud 1994). Here, the specific nature of live video is reduced to a more ambiguous representation, which could possibly act as a stand in real people and help the designer represent user contexts in which live filming has not been feasible.

Figure 38: In this sketch, LEGO mini figures are used in a stop motion sketch to frame the daily service routines of using a public employee program and illustrate the break downs in communication, simplifying the expression of the stakeholders in the process to refocus from the individual persons to the problem setting as a whole. See sketch at http://goo.gl/lUwUx5

We would argue that while they do not represent a future 'what if…' scenario, but stick to the 'as is…' of the present, these sketches still serve a sketching purpose for design. To adopt Schön's (1983) terminology of problem setting and problem solving, these sketches act as the designers' way of framing the temporal sequence of user actions and situations within which the further conceptual design ideas are created. As such, these scenarios act as the problem setting in animation-based sketching, forming the boundaries which can then be discussed by stakeholders and be reframed where necessary.

Future user Scenarios with a positive framing

This is the type of sketch we most commonly see as animation-based sketches. These sketches use animation to show how a proposed technology is used in context, acting as a diegetic element in a fixed scenario. The sketches are characterised as presenting the proposed idea from a perspective of being viable, feasible and desireable. The sketches vary in terms of whether the entire sketch is animated or whether there is a mix of live filmed elements and animated elements (aligned towards the mimetic end of Furniss's continuum).

Figure 39: The future of hospital care is explored through keyframe animating a series of diegetic elements, such as interfaces on the wall and tables, as well as the movement dynamics of an intelligent bed concept. The diegetic elements are shown in context with a live actor placed inside the animation-based scenario through green screen recording, showing an entire user journey as a patient using the new advanced concepts in the hospital. See sketch at http://goo.gl/oPJn7Z

These sketches also vary in terms of their narrative discourses and their communicative intent, as will be touched upon later in this chapter. What is important is that these sketches present a perspective on problem solving, asking 'what if we had X in this context'. Thus, these sketches frame a possible resolution to design problem, providing the positive perspective of a preferred future state on the information generated.

Future user Scenarios with a negative framing

These sketches are more or less identical to the future user scenarios just discussed, but with an important difference in how the proposed problem solving is framed. Some sketches are generated to either explore the possible disadvantages or to provoke us about the prospects of a proposed 'solution'. These sketches present a diegetic design concept in context and in use but show the negative sides of the possible implementation of a technology in the use context.

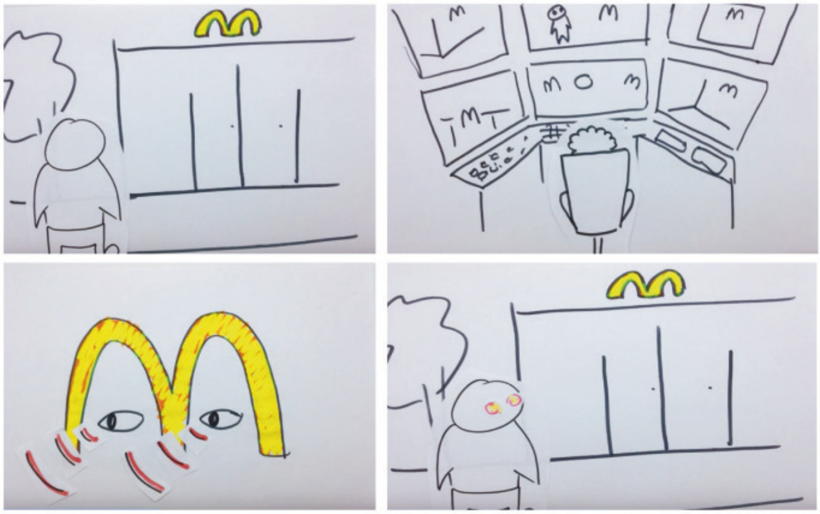


Figure 40: A simplistic sketch from the early concept development of digital service designs to prevent unethical use of persuasive customisation. The scenario uses stop motion to explore a scenario in which a large corporation is able to gather enough meta data about a bypassing citizen, to create a specially tailored offer, which persuades the citizen to buy. This sketch was made to clearly state the direction the designers would avoid to go in their efforts to create user customisation in shops. See sketch at https://goo.gl/dfCVgb

While often created as part of a more speculative or critical design practice (Dunne & Raby 2013, Markussen & Knutz 2013), such sketches can also be used to frame a continuum of solutions in the problem setting, thus representing the edge cases of undesirable future states.

A Systems perspective

The sketching perspectives introduced so far have focused on specific user scenarios - either as an indirect index of the interface and artifact interactions, or directly in animation-based user scenarios sketches. That is, they have been sketches which represent what Richard Buchanan labels 'interactions' among services, interfaces and artifacts (Buchanan 2001). However, sketches can also take on a broader perspective than the individual contexts of the users and instead generate information at what Buchanan describes as a 'systemic level' (Buchanan 2001). 'Systemic' in this regard is not understood as referring to digital systems, but rather to the systematical structure of organisations, groups and other stakeholders on a societal scale, which may be influenced by the proposed design. System perspective sketches use animation to facilitate an overview of the complexities of large systems, abstracting and distorting the systems to create a clearer conceptual model of the essential features of either the existing state or a new proposed state.

Figure 41: In this sketch, the designers envisioned a new digital service platform, connecting multiple different stakeholder platforms to ease the process of creating new ideas bottom up from the organisation. The designers depicted the possible break downs, and possible solutions by animating an overview of the abstracted flow of information between channels, people and contexts. See sketch at http://goo.gl/k04rds

While system sketches do not necessarily involve the exploration of new technologies, and thus fall out of our scope, we do also observe examples of sketches which explore the influence of new technologies on a systemic scale. For example, animation may be used to represent the flow of information between different societal stakeholders through a proposed service portal.

Five perspectives intertwined

The five perspectives presented form what we see as the 'genres' of animation-based sketching in the domain of generating temporal information about non-idiomatic technologies. In practice, the five perspectives are often mixed in the realised sketches - some starting by showing the present, moving on to later show the preferred future state. Others might zoom in and out between up-close interface and artifact interactions to show how these specific interactions affect the systematic scale.

The point of separating them into five specific perspectives is to point out the difference between the *sketch* and actually *sketching* it through animation in the first place. While a sketch might consist of multiple animation-based elements, each of these elements is itself a product of the designer's sketching process. This process is based on the contingent nature of design, dependent on choice and compromise (Buxton 2010). The designer has an *intent,* which we might relate to our matrix of the investigative, explorative, explanatory and persuasive functions of sketches.

When using animation-based sketching to sketch a certain proposed idea, the designer more or less deliberately frames the problem setting. Whether the aim is to acquire temporal feedback on a specific issue such as the non-idiomatic nature of a given interface interaction or it is to explore the user interactions mediated by a given technology in a given context, the designer's intent frames the perspective of the output sketch. The designer sketches to generate information that can reduce uncertainty, but the process gives the information a specific angle, indicating specific choices and compromises made. If the problem setting at the moment is the non-idiomatic nature of an interface, it would be superfluous and distracting to include too many contextual details. Likewise, if it is technological mediation in the use context which is in focus, the inclusion of details about the fine-grained interface interactions would be superfluous and distracting. Design researcher Bryan Lawson puts it this way: "*...it is usually helpful if the drawing does not show or suggest answers to questions which are not being asked at the time*" (Lawson 2006, 242). That is to say, if they are certain about a given matter, the designers' visual thinking through sketching is not aided by generating fine grained information about it. This is also true of animation-based sketching. The designer chooses which elements to include on the basis of the aim of the sketching process, and this forms the perspective of the sketch.

The animation-based sketches that we see are thus often in a more edited form than when then were originally part of the designer's animation-based sketching process. They have been digitally cut together to form a more coherent sketch. What started as individual and divergent investigative and explorative sketches might later be edited together to create a more explanatory or persuasive sketch which answers questions about the interface and artifact interactions or about positive and negative use scenarios. It may also provide a systematic overview.

STRUCTURE - LINEAR NARRATIVE ABOUT INTERACTIVE TECHNOLOGY

Building upon the five archetypical perspectives of animation-based sketching allows us to relate them to the overall structure of the sketches as a temporal sequence. We have previously analysed the perspectives of animation-based sketches in terms of the archetypical structure of a sketch (Vistisen et al 2016). Here we proposed a model showing the rather paradoxical nature of representing non-linear interactive technologies in the linear sequence of an animation. In the model, we fused some of the frequently used tools in explorative user-centred design; archetypical user *personas* (Cooper et al 2011, Nielsen 2012) and design scenarios (Carroll 2000), and explained their role in creating the *narrative of animation-based sketches* (figure 42).

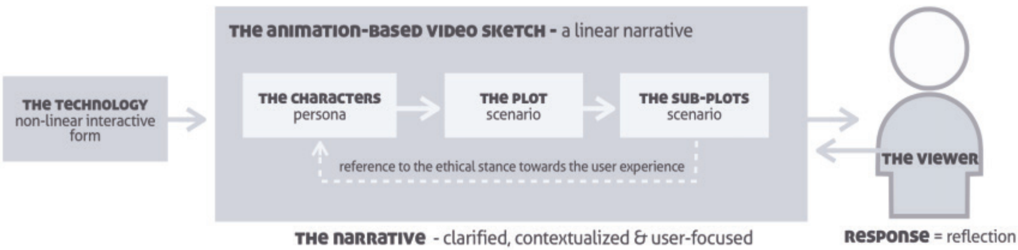


Figure 42: Framework for creating linear animation-based video sketches which explores new technological concepts with an emphasis on how the users are affected by the concepts, using the plots of the sketch to constantly refer back to the user stances explored (authors own model).

The persona becomes the characters in different scenarios, thus forming the main plot and sub-plots of the narrative of the use scenario. The interactive technology is inserted into this linear narrative, not just as another diegetic element, but as something which has agency of its own. In a classical narrative sense, based on Greimas' structural narratology (1983), the technology acts as the actantial 'helper' in helping the persona 'subject' to overcome the problem 'opponent' to achieve the preferred user experience as the desired 'objective'.

The animation-based sketch becomes a contextualised and user-focused narrative, telling story about addressing a specific problem in a specific manner. This is true regardless of perspective - a isoloated interface & artifact interaction sketch still implicitly implies the presence of a user who acts on the technology with an objective. In the animation-based sketch, the designer frames the problem and represents a proposed solution to the problem in a sequence. After sketching, the sketch becomes a piece of visual communication which encourages the designer, and other stakeholders to comment, critique and propose interpretations that were not consciously integrated in the sketch by the designer. This is why the model has double arrows between the viewer and the sketch: they indicate the common intent of all animation-based sketches, and sketches in general, to facilitate reflection. This is a different type of reflection than the reflection-in-action of designers while they are sketching animation-based sketches; in the latter, the reflections are based on constant choices and compromises in the dialectic between designer and design material.

The viewer's reflection is more akin to reflection in *design critique* (Sennet 2008, Buxton 2010), in which peers comment and act upon the sketches, annotating the sketch with additional information. Some of the viewers might be design peers, able to *read* sketches as sketches and provide precise design critique. Others will be stakeholders from widely different knowledge domains and thus with different foundations for reading and responding to sketches than trained designers (Buxton 2010). That is not to say that the reflections the animation-based sketches invoke in such viewers are uninformed or 'bad'. Rather, they indicate the sensitivity required of the designer in creating a design compromise that balances different knowledge domains and perspectives on the problem. The sequentiality of animation arguably helps create a frame of reference akin to watching a movie, which makes it more natural for most non-designers to form an opinion than rough sketches. Ylirisky & Buur (2007) presented a similar argument about the temporal medium of video as a tool to facilitate a more conscious design process.

The viewers' reflections should enable them to reveal the possible blind spots and ambiguities in the way the designers have framed sketches. Thus, the viewers' reflections upon animation-based sketches are actually reflections upon the intent behind the sketch, as much as they are reflections on the idea expressed.. This is positive, since it incorporates the narrative structure of generating temporal information through animation-based sketching. The viewer interprets both the narrative plot (the proposed idea) and the discourse of *how the plot is told* as a single coherent *narrative discourse* (Genette 1983). The viewers' response to the narrative discourse of animation-based sketches reveals yet another aspect of the archetypical animation-based sketch for us to discuss - the common discourses that are applied.

NARRATIVE DISCOURSES IN ANIMATION-BASED SKETCHES

Earlier in the book, we touched upon David Kirby's (2010) concept of technologies described as 'diegetic'. The term "diegetic" derives from literature and theatre studies and refers to a product whose functions and implementation are true within the ontological boundaries of the narrative of which it is part. A narrative has a story, but it also has all the settings, places, props, technologies, and other signs to support that story (Kirby 2010). Kirby uses the term 'diegetic prototypes' about such diegetic elements in his analysis of science fiction films, in which the visual fidelity of the portrayed technology is too high for the portrayal to be viewed as sketching. However, the terminology is applicable to sketches and prototypes since it describes the discursive way a narrative might *'tell'* us about the potential of new design ideas. This happens in combination with the aforementioned theory of 'possible worlds' (Ryan 1991, Dolezel 1998, Pavel 1975). Herein also the plausibility of the diegetic technological concept if realised.

For example, an imagined design scenarios in which we used a non-existing technology to achieve faster-than-light travel would break the ontological laws of physics and would thus be part of an inaccessible world. On the other hand, a scenario in which we proposed to use an emerging non-idiomatic technology to solve a problem in a given context in a novel way would be ontologically sound and thus be part of an accessible possible world. Thus, diegetic elements in design scenarios differ from those in speculative scenarios which use animation to create seemingly plausible concepts but whose ontological rules differ from our reality. Kirby argues that a diegetic design exists to show that a technology can exist in the real world and has a rhetoric aimed at facilitating discussions about this viability (Kirby 2010). In other words, a focus on the diegetics of the designed elements creates certain discourses through which the animation-based sketch can be expressed.

From our sampling of animation-based sketches, we have inductively categorised patterns of narrative structures which adhere to different ways of dealing with discursive elements such as *frequency, order, voice, mood* and *duration* (Genette 1983). Through this process, we have induced at least six different discursive formations describing how the narrative in animation-based sketches is *told*.

In accordance with genres of common storytelling discourses, we labeled these sketching discourses as:

- *Natural*
- *Documentary*
- *Instructional*
- *Promotional*
- *Dramatic*
- *Comedic*

Again, we will provide a short exemplification of each discourse below.

Natural

Natural discourse seeks to reduce the number of extra-diegetic elements in the sketch, that is, elements which comment on the narrative and exist outside it (e.g. voice over). This discourse of telling involves seeking to establish perception that is as neutral as possible. Technology is shown in use, but how it solves a specific problem is not explicitly shown, and there is not even any indication -that we should focus on the proposed technology. This discourse mostly occurs in the user scenarios perspectives, both positive and negative, but it is also present in some interface & artifact interaction sketches, where the sketch is just showing interactions without much sense of sequence or consequence for the user.

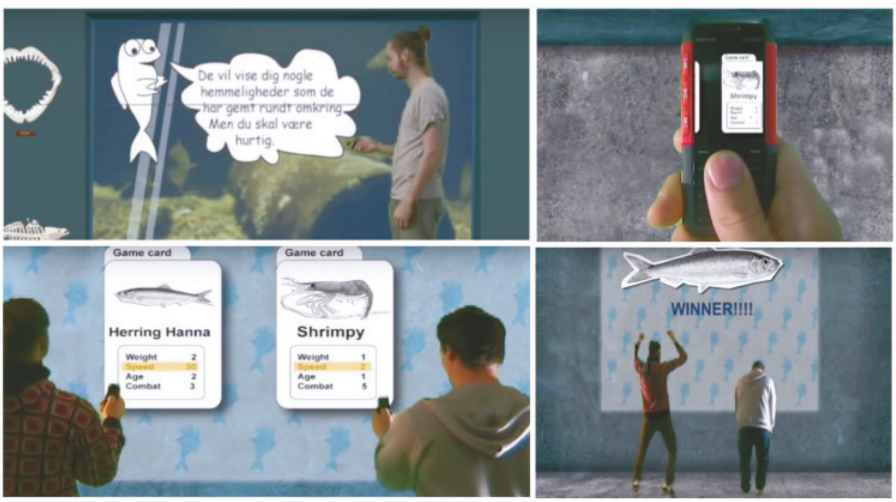


Figure 43: This sketch depicts a user journey through a digitally augmented North Sea Oceanarium aqua zoo. The two users er shown interacting with a series of proposed interactive assistents and mobile experience zones. This is done with no narration, text signs or other non-diegetic elements, establishing a natural setting of the sketch. See sketch at http://goo.gl/HWezsG

This discourse is obviously the most ambiguous of the five, since it leaves extensive gaps for the viewer to fill interpretively, in regard to both the point of viewing the sketch (the plot) and the idea behind the sketch. Consequently, this discourse seems best suited to the investigative and explorative functions of sketching, and less for explaining and persuasion.

Documentary

The discourse of documentary film is often employed when designers use video in design processes (Ylirisky & Buur 2007, Bolvig & Botin 2015). This "creative treatment of actuality" (Ylirisky & Buur 2007) traditionally forms a contract with the viewer that the events portrayed will, to some extent, be identifiable in reality. In these cases, it is not the contract of actuality and factuality with the viewer, but rather the discursive element of telling 'worlds' instead of 'stories' (Sterling 2013) which is driving the discourse.

Figure 44: This sketch uses 3D animation from a level editor of a game engine to portray a documentary walk-through of the 'park of the future'. An animated flyover is portrayed as a very fact-based portrayal of the possible future of the park area of Marselisborg. See sketch at http://goo.gl/x3CkMb

The documentary discourse has multiple variations, such as the presence and role of the narrator, which can be present or stand outside the diegetic elements of documentary. Animation-based sketches which employ this narrative discourse are often used to portray the perspective of a user scenario of the present, since such sketches fits the documentary goal of presenting actuality from a certain perspective. However, some has authors have claimed that fiction elements in documentary can provide a 'documentary of the near future' (Kirby 2010, Forlano 2013).

Instructional

This discourse adopts the same style of telling as many of the animation-based learning concepts discussed in chapter 4, in which animation is used to walk the viewer through the use case of a technology. These sketches undertake a step-by-step walkthrough of the different elements of interactions with the technology in a normative description of how it should be used. The difference between traditional instructional animations and the discourse used in sketches is the shift in focus, from instruction about 'what is…' to instructions about 'what could be'.

This discourse mostly occurs in user scenarios of the future with a positive perspective and in interface & artifact interaction perspectives. It is quite clear that the discourse is applied to 'mimic' the discourse of traditional instructional animations, leveraging structure, diegetic elements of voice over, text signs and extrapolations to express the use case of the technology.

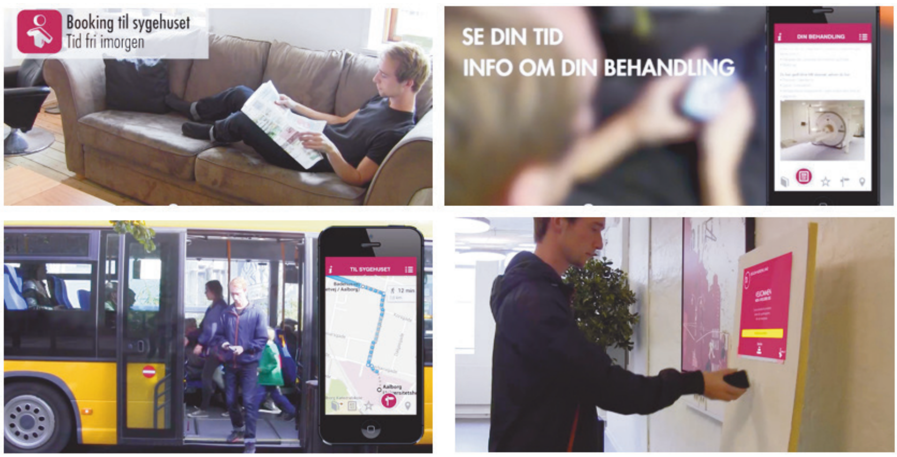


Figure 45: This sketch explores a digital wayfinding solution aimed at reducing wait time at hospitals. Cutting through multiple contextes, the video is supported by animated diegetic interface elements, as well as non-diegetic overlays describing the user journey step by step. As such, the animation-based sketch functions almost as a instruction video, if the proposed concept was to be realised. See the sketch at http://goo.gl/2KBJSA

The normative nature of this discourse removes much ambiguity: the sketch 'tells' the viewer something specific, rather than exploring an unfinished concept. Consequently, animation-based sketches using the instructional discourse often fall into the trap of becoming too specific - that is, unless they adopt a rough visual fidelity to set the balance between the normative discourse and the aesthetic appearance of the expressed idea.

Promotional

In the same way as instructional discourse borrows from its non-sketch counterpart, promotional discourse also draws heavily on marketing and the advertising of actual products. This discourse has a clearly persuasive intent and employs tropes aimed rhetorically to gain traction, support and funding for the concepts realisation. Promotional discourse uses animation-based sketching to frame narratives which show the proposed idea from its best sides and hides its ambiguity and unanswered questions. Animation-based sketches using this discourse are in fact often only sketches by virtue of their visual fidelity - they look like sketches - while their intent is more or less solely to gain acceptance by persuasion. Thedanger is that the viewer may be persuaded into thinking that the proposed idea is actually real and realised as it is, a phenomenon typically referred to as 'vapourware' (Sterling 2013). Animation-based sketches with a promotional discourse use fiction in the theatrical sense but must avoid to being perceived as fact.

Figure 46: This sketch explores a concept for a gesture controlled interactive television, where the gestures are inspired by the directing motions of a musical maestro. The sketch initiates by presenting the physical remote, and then continues on to highlight the features via a series of keyframed interaction examples. The animation is more polished and uniform in its techniques and materials, creating an expression which could be easily mistaken as a real promotion of a real product. See sketch at http://goo.gl/XllCRX

This illustrates a paradox of both promotional discourse, and the persuasive function of sketching in general: can they really be thought of as sketches? A way to establish that it is fair to use the concept of sketching in relation to expressions with a persuasive intent can be found by returning to Bruce Sterling's analysis of 'design fiction'. Design fiction is *"the deliberate use of diegetic prototypes to suspend disbelief about change"* (Sterling 2011). The important part here is the 'suspension of disbelief', since it tells us that the use of fiction to express design ideas has a built-in ethics. An animation-based sketch with a promotional discourse can 'advertise the near future' as a creative way of taking the viewer into proposed conceptual space, and then letting them go again to reflect upon what was experienced again. Sherdrof & Noessel (2012) further argue that such fictions enable the viewer to look for ways to apologise for the design; that is, they think about ways in which the design could work in the way it is depicted, if it were to be realised. We use what works in a promotional narrative discourse to arrive at new ideas and decisions. As vehicles that aim to enable reflections about preferred future states by overcoming the barriers formed by preconceptions, promotional discourse and persuasive intent are arguably a viable mode of animation-based sketching.

Comedic

This discourse leverages the qualities and tropes of popular fiction to create an engaging narrative about the proposed technology by using humour as both a disarming and ambiguous instrument. These sketches often use slap stick elements, in which the persona characters in the animation-based sketch 'fool around' or ironically show the role of the proposed idea in context. In animation-based sketches of both positive and negative user scenarios, the comedic discourse can serve to emphasise the nature of the sequence as a 'sketch'. This is also noted by other scholars such as Buxton (2010) and Laurel (1993), who examine the role of play in design processes and its frequently humorous side effects. While the trope of narrative comedy is as old as storytelling itself (Aristotle 1996), when used for sketching this discourse sometimes affects the output sketches in a less favorable manner. The risk is that the comedic discourse may divert attention from the proposed design idea so that the animation-based sketch essentially becomes nothing more than a comedic 'sketch'. Nevertheless, animation-based sketches using comedic discourse in tandem with enactments such as bodystorming (Oulasvirta et al 2003) seem to support the process when there is an explorative intent behind the sketches.

The comedic discourse may lower the participatory barrier for some to act out the idea in a user scenario perspective, augmenting the acting with animated effects to support the explorations (figure 47).

Figure 47: A sketch portraying a gamification concept aimed a facilitating partent to child conversation about the negative effects of narcotics. The sketch uses keyframed animation of the mobile game interface and game elements, but uses a highly ironic tone in both the graphism, the animated effects, and the live actors responses to the animated content. This creates a more comedic take on the concept idea, underscoring the sketchy nature, but also questions the the validity of the idea. See the sketch at http://goo.gl/QdEABl

Its often slapstick appearance and lack of explanatory focus should not lead comedic discourse to be discounted if the process of making the sketch has a beneficial investigative and explorative function internally in the design team. It remains however, a discourse which walks a fine line between using humour to suspend disbelief and simply distracting focus from the idea.

Dramatic

Dramatic discourse uses storytelling to make user scenarios from either positive or negative perspectives come to life in a poetic structure resembling classic narrative structures such as the actantial model (Greimas 1983) and the Hollywood model (Harms-Larsen 2003). These sketches take on the properties of other types of dramatic content, like animated feature films, by employing characters, conflict and actions to dissolve the conflict. While the four other discourses also uses narrative structure to a greater or lesser degree, dramatic discourse does not break the narrative in the same way as the 'sales pitch' of promotional discours or the 'step by step guide' of instructional discours (figure 48).

Figure 48: This sketch depicts a user journey through an augmented reality experience at cultural heritage context, in which the sketch is organised as a clear narrative. The users go through the full user journey, and the live actors act like they are fully immersed in the experience. The dramatic structure of a beginning, middle and end is clearly present, and the use of various animation techniques are used to support diegetic elements at each phase. See sketch at http://goo.gl/64Ga6o

Dramatic discourse could be seen as a 'meta discourse' for the other four discourses, since the dramatic structure forms the basis of most other story telling structures (Aristotle 1996). This means that just as one animation-based sketch can combine several perspectives,, it can also contain more than one discourse, but mostly with the narrative discourse as the foundational layer.

However, the dramatic discourse of animation-based sketching differs from the dramatic discourse of traditional storytelling, since the character personas in the sketch share the lead role with the proposed technology, which is normally 'just a diegetic prop' in the story. The central role of the diegetic design indicates that the sketching of the sketch has not been undertaken to construct a compelling drama for an audience to experience. Instead is has been to construct a drama around the diegetic element and to get people to concentrate on how that technology enables the drama - rather than how the entire story world unfolds. Thus, the dramatic discourse is not aimed at fiction: it is aimed at design and uses fiction to get there.

A narrative about 'what could be'

Supporting the design process is central to all five discourses. Whether the intended function of the animation-based sketches is investigative, explorative, explanatory or persuasive, the perspective and narrative discourses serve as a frame of reference for the evaluation of the potential facts of the design proposal. When used to explore non-idiomatic temporal issues involved in the interaction design of a new technology and the user experience in a given context, the discourse helps us create materialised thought experiments (Bleecker 2009) about 'what could be'. As touched upon earlier in this book, the abductive sensemaking of design synthesis, is thus manifested in the way in which the animation-based sketches tell a story about these thought experiments. They amount to qualified guesses: 'If these conditions were in place, these events might occur for the users in this context'. Moreover, they allow the designer and others to reflect upon the utility, usability and desirability of that outcome.

VISUAL VS. TEMPORAL FIDELITY

The abductive logic of the arguments presented by animation-based sketches is based on the way in which the perspective tells us *what* the sketch expresses, and on the narrative discourse telling *how* it is expressed. There is however also an important addition to this argument in the aesthetic *looks* of the sketch. Thus, one last thing to discuss about the general anatomy of an animation-based sketch is the fidelity of the different rendering styles commonly used in the sketches we have sampled.

As one of his central arguments, Buxton completely dismisses the notion of 'high' and 'low' fidelity renderings in design and instead proposes that any appropriately used technique is always the 'right fidelity' (Buxton 2010, 295). He does so in referencing McCloud's concept of *amplification through simplification,* which we also touched upon earlier in this book (McCloud 1994). Buxton argues that the fidelity of a sketched rendering can actually be higher than reality in terms of experiential feedback about the design problem in early design. We agree with this notion but still argue that the distinctions in fidelity are valid distinctions, especially in regard to animation-based sketching. Creating even a crude and simple animation takes longer than, say, drawing a crude stick man on a piece of paper. Consequently, we argue that animation-based sketching involves at least two types of fidelity: visual fidelity and temporal fidelity.

It is visual fidelity that is discussed in most studies which address the fidelity issue (Walker et al 2002, Sefelin et al 2003, Rudd & Isensee 1996). The question concerns how 'finished' the produced sketch (or prototype for that matter) looks in terms of rendering quality. A hand drawn paper sketch with jaggy lines in black and white would be considered low fidelity, and a Photoshop drawn computer wireframe with clear typography and iconography would be considered high fidelity. As discussed previously, one cannot judge one approach to be inherently better than the other, since the value is completely dependent on the questions raised at a given time in the process. It makes more sense to conclude that the sketching approach and the sketch output clearly speak in a visual vocabulary and that it is through this vocabulary that the sketch informs us of the character of its fidelity. Buxton includes an intriguing example of the sketches of a new mountain bike prototype, which gradually evolve from a rough drawing to a more and more refined model in a CAD drawing software program (Buxton 2010, 110).

Figure 49: Buxton's examples of gradually more and more refined renderings of a mountain bike.

Buxton shows that the sketches of the same product tells us inherently different things about the issues each addresses, some concerned with the overall concept ('this is just one of our many ideas') and others concerned with details ('this specific structure in the idea needs special focus'). The point is that the way a sketch 'speaks' to us about its fidelity helps us decide how to approach the sketch in our reflections - should we put the details under scrutiny or focus on the overall concept? During sketching as a reflective process, the level of fidelity also determines which aspects of the design problem the designer will address at a given time and which will be left out. In a sense, visual fidelity is actually what defines the framing of the design setting in sketching.

Temporal fidelity is a tangent to visual fidelity. In design situations without established idioms for how the dynamics of a digital technology will affect the users interaction and user experience in context, visual fidelity is not the only variable. Whether they employ deep graphical detail or only use crude and unfinished renderings, static sketches only expresses aspects about interactions and dynamics to the extent that available idioms act as frames of reference. Animation-based sketching generates temporal information to fill these non-idiomatic gaps.

When dealing with non-idiomatic design problems of temporality, the designer frames the design problem in terms of the level of temporal fidelity of the specific animation-based sketching techniques, materials and tools applied. Thus it makes sense to describe temporal fidelity in terms of 'low' and 'high', as one does with visual fidelity. It might be argued that the fidelity of apparent movement and change is also an aspect of visual fidelity. In non-idiomatic design situations, however, it makes sense to separate the two fidelities, since we might mix a low-fidelity visual representation with a high-fidelity temporal expression, and vice versa. In the designer's sketching, it might make sense to take hand drawn visuals and use animation to move elements around to explore the details of a proposed interaction modality. In the same way, the temporal fidelity of an animation-based sketch tells other stakeholders something about which aspects of the dynamics in the design provide the focus of the sketch, thus guiding their interpretations, critique and proposals towards the appropriate temporal aspect.

Temporal fidelity and visual fidelity are thus two central aspects in the abductive sensemaking of animation-based sketching, indicating which details of the argument to focus on, and the level of detail required to assess their index to reality.

CHOICES ON ALL ANATOMICAL LEVELS

We have now discussed four fundamental anatomical aspects of animation-based sketches: perspective, discourse, intent and fidelity. Each aspect allows deeper reflections on other sub-categories than the ones presented, such as specific animation techniques, specific repetitive storytelling aspects, and ways of combining different aspects in the same sketch. We argue, however, that these aspects constitute the macro level aspects that an animation-based sketch can represent. What can be derived from the four aspects is a return to our notion of the contingency of design and to Buxton's notion of 'design as choice' (Buxton 2010, 145).

Given that the animation-based sketch inserts a non-linear technology into a linear sequence, the perspective, discourse, intent and fidelity of this sequence are all based upon non-coincidental choices by the designer. Sometimes the choices might be made to frame a certain aspect of the non-idiomatic problem in the way that is most practical for the designer. At other times the choices might be based upon a wish to portray the interaction design of an idea and user experience as elegantly as possible. In either case, in the use of animation to emulate a digital system by creating a narrative sequence, complete objectivity can never really be achieved. Just as animation can never be neutral (Wells 1998), the choice of what to sketch and how to sketch involves choosing something and leaving something else out. Design sketching, and especially animation-based sketching, is all about these contingent choices throughout the design process before the production of a realised 'product', which stands as the fossilised remains of all the choices made.on the journey to completion.

The aspects of animation-based sketching on a macro level, which we have proposed on the basis of the sampled sketches can now be viewed as series of categories. The categories are not meant to read as a strict scheme, but rather as a way of highlighting the different mix of choices that are possible. On the horizontal level, we can describe a given animation-based sketch by highlighting its use of one or more of each of the vertical aspects, thus describing its overall anatomy.

PERSPECTIVE	DISCOURSE	INTENT	FIDELITY
Isolated interface & artifact interaction	Natural	Investigative	High Visual
Use scenario - present	Documentary	Explorative	Low visual
Use scenario - positive	Instructional	Explanatory	
Use scenario - negative	Comedic	Persuasive	High Temporal
Systemic view	Dramatic		Low Temporal

Figure 50: The final diagram of the anatomy of animation-based sketches, with five perspectives, five discourses, four intended functions, and four types of fidelity.

This anatomy does not specify the technical aspects of how the animations were done or the reflective process in which the designer may have iterated back and forth in the production environment. Instead, it gives us a tentative overview of the potential structures that an animation-based sketch might assume when creating an abductive argument of 'what if?' is proposed. This argument contains temporal information from a given perspective with a given fidelity, a given discourse, and a given intent.

ANIMATION-BASED SKETCHING - A DISTINCTIVE APPROACH

We have now reached the end of part II of this book, and reached a definition of animation-based sketching.

> **ANIMATION-BASED SKETCHING IS DEFINED AS:**
>
> *Using animation to portray a fictional reality that is intended to become factual*

Furthermore, we have distinguished between animation-based sketching and the concept of functional animation. Even though animation-based sketching and the way in which functional animation uses animation outside the scope of entertainment and art overlap, , animation-based sketching differs in that it is still closely related to the use of animation in the fictional domain. This kinship to animated fiction is further evident in our mapping of archetypical animation-based sketches, which take on perspectives and discourses from narrative genres of fiction. In other words, animation-based sketching in its many variations occupies its own ontological place in animation and design studies.

The final part of the book moves from theoretical studies of animation-based sketching to an examination of the practical application in design processes.

PART III: APPLICATIONS

The third part of this book turns to the applied side of animation-based sketching in search of practice-based examples of the multitude of methods, techniques and tools that can be used for sketching with animation. This section draws on examples from empirical material, and it reports small-scale experiments that showcase specifics techniques as well as the design knowledge we can extract by use of the technique in design sketching.

We begin by discussing the core principles of digital production environments that are suitable for animation-based sketching. This allows us to assess the important distinction between being able to make something which looks like a sketch and actually being able to conduct the process of sketching as visual thinking in a digital production environment.

Subsequently, we present the results from two workshop experiments in which we explore how animation-based sketching can be applied by designers with little animation expertise. We also assess the potential of adopting animation-based sketching as a viable design approach. We pursue the same line in examining two case studies from praxis. The case studies explore various attempts to apply animation-based sketching in praxis.

These empirical investigations were conducted as explorative studies that sought to 'expand' knowledge about the field of animation-based sketching in practice. We borrowed this notion from Krogh et al (2015) and their notion of 'drifting' in design research, which involves letting the empirical observations take us through multiple different instances of the animation-based sketching being applied. These observations are not necessarily linked, especially not between the different cases, but, in their disparate areas of concern, they all support the expansion of knowledge about animation-based sketching.

CHAPTER 9
THE PRODUCTION ENVIRONMENT

In this chapter, we discuss some of the quality criteria for the digital production environments of animation-based sketching. Rather than investigating the features of specific software packages in depth, we seek instead to condense the features needed in present and future production environments to enable both the production of sketches and a reflective sketching process. We identify an *interactive timeline, live preview, component libraries, reusable components and animations,* and *sketching in layers* as fundamental criteria a production environment must adhere to in order to accommodate animation-based sketching.

These quality criteria are not necessarily existing in all production environments, which is why we often see animation-based sketching being conducted through a multitude of different software and hardware environments.

THE CHALLENGE OF DIGITAL SKETCHING

Sampling digital design software and providing informed commentary about that software involves a race against obsolescence. Whenever a new set of instructions or a new guide book is published, it only remain relevant until the next version of the software changes everything, or until a new piece of software completely replaces it. The same often goes for design literature which attempts to recommend software to operationalise the principles, methods and theoretical frameworks presented for a design topic (see Unger 2009, Buxton 2010, Löwgren & Stolterman 2004, Greenberg et al 2012). These recommendations tend to become obsolete after only a few years, and the principles and interactions are not transferable to other software packages. Consequently, we will not examine the specific details of examples of digital software for use in animation-based sketching, or the guides to their use. Rather, we will seek to discuss some of the qualities that we argue must be present in the production environment of animation-based sketching to facilitate the reflective practice of sketching and to enable the myriad of different animation techniques applicable in design.

When it comes to broadening the concept of sketching, digital sketching environments have long been of interest to the design community (Goldschmidt 1994, Djik 1995, Landay & Myers 1995). Goldschmidt (1994) argued that no computerised tool could surpass the visual thinking enabled by sketching but that the computer might be adapted to simulate the qualities of sketching to the point of allowing visual thinking on a par with pen and paper - or even better.

The problem, however, has precisely been that much of the ambition in digital sketching has been directed at replicating the qualities of pen and paper in digital formats (Wu et al 2012, Djik 1995, Jonson 2005). Arguably, this could in part be because of the more specialised competencies required to use digital software for design. Coyne et al. (2002) found in their studies, that lac of experience with computing seemed to limit design capabilities. Using digital tools demands a form of digital literacy that requires the designer to understand different conceptual models for each type of software applied. This amounts to a rise in complexity from sketching thoughts down on paper.

A focus on reproducing or remediating pen and paper may lead to a failure to notice important ways in which digital systems have the potential to facilitate sketching. Landay & Myers (1995) suggested the need for computerised tools, which allow rough design ideas to be sketched quickly while offering the features associated with digitals tools: *easy to edit, store, duplicate, modify,* and *search*. As such, computer-based sketching tools should leave the 'design memory' embedded in the discrete interactions with the software, thus producing a memory of the *design moves* in the terms proposed by Schön & Wiggins (1992). Design moves reducing uncertainty about the problem setting and problem solving possibilities do not need to be constrained to simulated pen & paper on a monitor: they can also be applied to the process involved (e.g. digital animation), thus facilitating temporal sketching.

Can digital sketches be investigative?

In Chapter 1, we discussed the four functions of sketching derived from Olofsson & Sjölen's (2007) categorisations, and there we argued that these functions changed according to the situation in which the sketch was used. This represented the intertwined relation between sketching as visual thinking and sketching as visual communication. An investigative sketch made by a designer as a way of thinking through a design problem might later be used as the basis for an explanatory sketch shown to an external stakeholder. It could be adapted by just adding a few annotations and pitching it differently.

The investigative function of sketching is interesting when it comes to digital sketching, that is, sketching with a material which has no material qualities in itself. As Landay and Myers (1995) have suggested, computerised sketching potentially gives the same editing variables and manipulative variables as any other digital production environment. In essence, this mean that in the creation of a sketch in a digital production environment, 'the sketch' never really exists until it is saved or exported into a finite output version. During the process, digital sketching may involve a constant flux of different design moves captured in a material which can change in an instant and erase any trace of what was sketched. This is very different from traditional pen and paper sketching, or, for that matter, sketching in almost any physical material. In sketching on paper, design moves are captured physically, and they stay captured alongside the next sketch or the annotations on top of the first. This raises a question: can digital sketches ever really be said to be investigative, or do investigative sketches only exist momentarily in the digital sketching process itself?

At the very least, it seems reasonable to suggest that digital sketching in almost any form is different from analogue in terms of investigative intent, in that it it does not 'save' the design moves unless the designer or the production environment deliberately chooses to do so, creating a fixed *version* of the digital sketch. This adheres to what media philosopher Lev Manovich has labeled *the variation principles* of the digital medium:

> *"A new media object is not something fixed once and for all but can exist in different, potentially infinite, versions"*
>
> (Manovich, 2001, 36.

If one adopts this train of thought, a digital sketch can be defined as a new media object which can exist in potentially infinite versions. This challenges the capturing of the investigative sketches done via digital sketching. This important challenge leads us to an examination of the inherent qualities of the multitude of potential production environments for animation-based sketching.

LESSON LEARNED:

The ***design moves of a digital sketch are not fixed*** *in the same way as in static (physical) sketching. A digital sketch is essentially only investigative while the designer is sketching inside the production environment, unless the designer or the production environment constantly creates output versions of every design move.*

THE PRODUCTION ENVIRONMENT

We have already briefly discussed animation software such as K-Sketch (Davis et al 2008), 'Sketch-n-Stretch' (Sohn & Choy 2010) and idAnimate (Quevedo-Fernández & Martens 2012) as dedicated animation-based sketching environments.

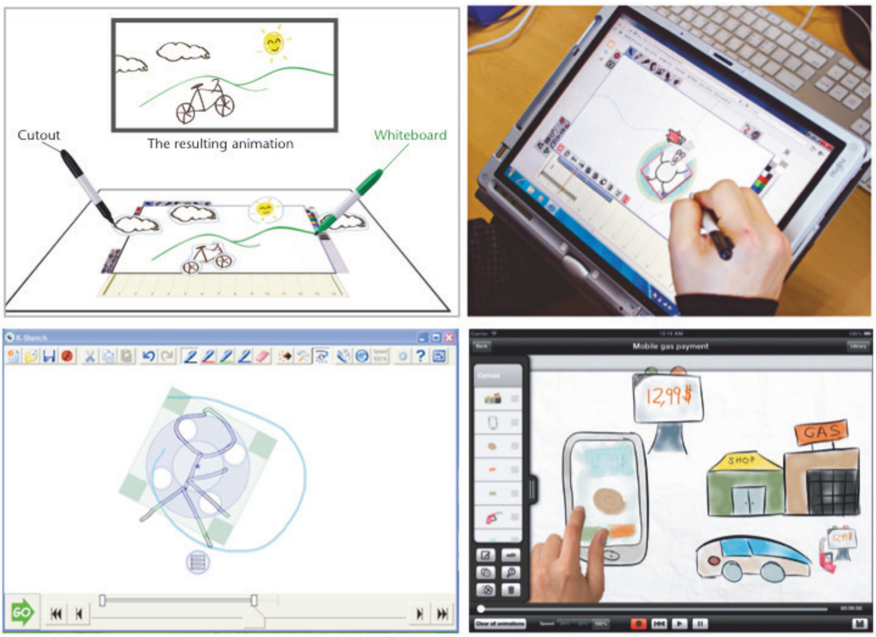


Figure 51: The examples of Stretch n' Sketch, K-Sketch and idAnimate - all specialised production environments for using animation in design sketching.

As we said earlier, these software contributions deserve praise for their attempt to lower both the participatory barrier and the time cost of creating animation, but they also limit the sketching process to a few materials or techniques. As production environments, however, animation and authoring software do illustrate some of the essential features needed to enable animation-based sketching.

The interactive timeline

First and foremost, all the previous approximations enable an iterative back and forth process in activities by representing a *timeline* in the production environment. The timeline allows the designer to obtain temporal feedback on the arrangement of graphic positions by iteratively cycling back and forth in design moves. This enables the investigative function of sketching, and we would argue that it enables reflection-in-action for the animation-based sketching process. Not limited by sequential playback and with the possibility to preview and adjust the arranged positions, the designer constructs new information in a reflective dialogue with the digital material. This echoes the lessons learned from the studies of animation-based learning, where Tversky et al (2002) found that *interactivity* was essential for the students' understanding of the phenomenon. Likewise, the ability of the timeline to facilitate the production of easy-to-edit material in iterative design moves is enabled by interactivity between graphical content and the arrangement of movement and change in that content.

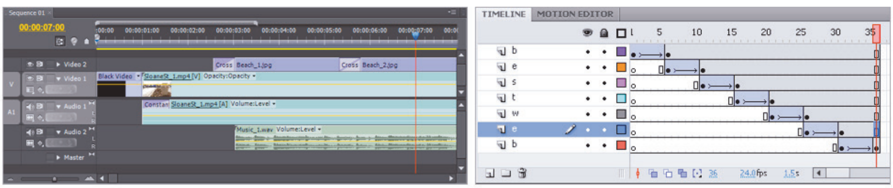


Figure 52: Examples of interactive timelines in Adobe Premiere (left) and Adobe Flash (right), enabling back and forth exploration of the configured motion.

The interactive timeline is an essential quality, but it can be replaced. Promising results have been obtained in recent attempts to sketch using responsive code (Lindel 2012, Forsén et al 2010) in production environments which combine animation with code. Here the timeline is replaced by algorithmic variables which give the designer the same iterative back and forth adjustments of the animated positions as afforded by a timeline. Designer and academic Bret Victor has produced an intriguing example of code-based sketching of temporal information (Victor, 2012).

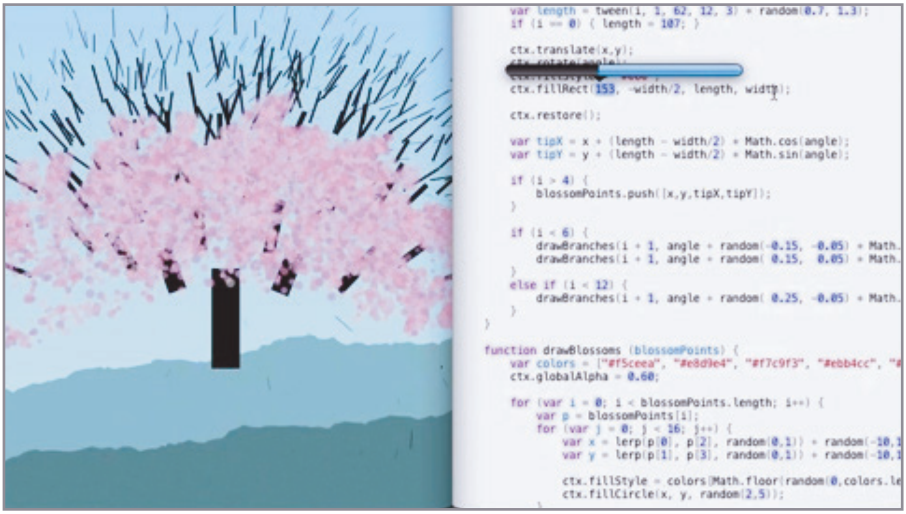


Figure 53: Bret Victor's demo software showcasing how interactive control of the configuration of the animation does not necessarily bound to a timeline metaphor, but might as well be enabled by responsive program code.

Although only exhibited as a closed setup, Victor's demo shows that what we label 'interactive timeline control' might easily be replaced by other interactive features enabling the iterative feedback loop of sketching. The important aspect of this criterion is direct temporal control, the ability to go back and make quick adjustments without having to redo the animation completely, and live preview. Live preview is important enough to constitute a quality criterion in its own right.

Live-preview

Another feature of animation-based sketching environments that can be derived from the importance of interactivity in the timeline or from variables that control features akin to the timeline is the capability of *live-preview*. Live-view is a basic feature of many video editing environments, where the applied changes to a video clip (e.g. the cut between to clips or the adding of colour filter) are rendered and displayed live or close to live. In most video editing software, the ability to live preview is determined by the processing power of the hardware running the machine; that is to say, faster hardware allows live-preview of a larger amount of content. In production environments traditionally used for animation, however, the fidelity of the content to be animated is often so high and the motion to be created so complex that live preview is not feasible. In the animation of a complex 3D figure with high resolution textures, the animation of the pose-to-pose animation can only be achieved using commonly available hardware by *rendering* the sequence. Rendering calculates all the changes in the sequence, frame by frame, and often makes the production environment unavailable in the meantime.

This is acceptable and more or less part of practice for animators, movie editors and other practitioners using authoring software in general. In design sketching, however, the lack of design preview essentially rules out reflective practice. When the designer is required to wait for a sketched sequence to be rendered or is held back by a preview which does not run at live speed, the iterative adjustment of positions is limited, as is the reflective dialogue with the material. The lack of live-preview leads to another type of reflective process, in which the designer develops the idea, maybe in another medium, and plans its execution prior to using the animation production environment. In this way, the output might both look like an animation-based sketch and be framed as a proposal, both in terms of Buxton's sketching characteristics and in accordance with the optic of information generation. Thus, it could be described as an animation-based sketch, but it would not qualify as a product of animation-based sketching, since only limited reflective practice was possible in the production environment.

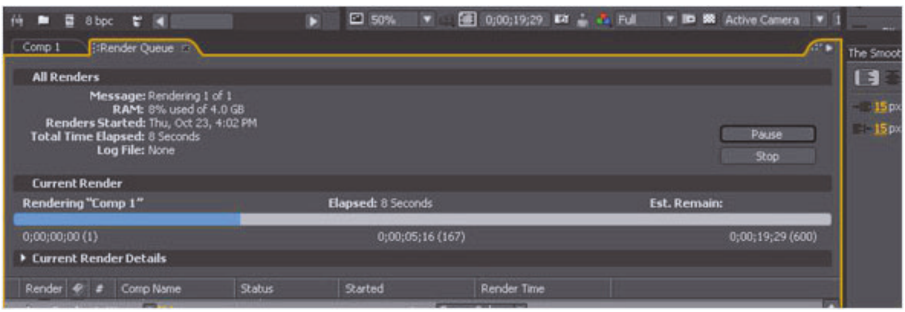


Figure 54: An example of Adobe After Effects, and the 'RAM rendering' process necessary to preview animated content, making it hard to get immediate feedback from the sketching material.

It may be useful to compare two examples of production environments: Adobe Premiere Pro and Adobe After Effects (adobe.com). Although they look alike, they create different sketching conditions. We set out to create a quick conceptual mobile app sketch in both production environments. We used the timeline and the different features of the software packages to animate movement in the interface and in some effects in the context. In Adobe Premiere, which offers video editing with limited animation capabilities, we were able to sketch back and forth in the timeline, investigating different ways in which the app interface would behave with constant live-preview. Through the live-preview, we constantly generated temporal information and received temporal feedback in what we would argue was a reflective dialogue with the material. In Adobe After Effects, which is specifically aimed at creating special effects, we were quickly forced to render our production to preview the interface behaviour. In other words, we had to break off from our sketching process for a while to gain temporal feedback, then return to make new configurations, and then break the sketching process for a new rendering. While the temporal fidelity of the information generated through After Effects was arguably more detailed and fine grained, the process of creating the sketches was a constant process of imagining how something should be and then just executing it; that is, it was production rather than sketching.

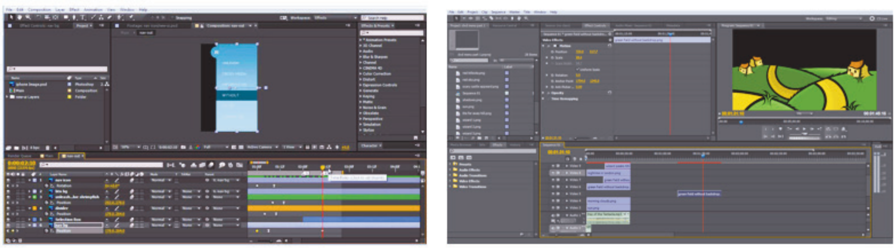


Figure 55: Adobe After Effects (left) and Adobe Premiere (right) both featuring the timeline metaphor, but with Adobe Premiere able to live preview simple animations, whereas After Effects can make more complex animations, but with limited live preview for feedback in the sketching process.

This demonstrates the importance of live preview for the use of digital production environments in sketching and especially why it is essential for sketching with animation. If the designer cannot reflect-in-action but constantly faces 'break downs' in the design tools, the reflective practice of sketching will be inhibited. Löwgren expressed similar concerns in reflecting upon his experiences with animated use sketches (Löwgren 2004); they took more than 24 work hours to complete. Löwgren notes that while the animated use sketches looked like sketches, their purpose was to visually communicate the tentativeness of the idea, not a characteristic of actual the process.

Of course, one might argue that this comparison merely reflects the fact that the hardware running the software is not equally potent: a stronger computer could probably enable universal live-preview in Adobe After Effects. While this might be true here and for other potential advanced production environments for sketching such as 3D Studio Max and Maya (autodesk.com), it does not change the fact that live-preview is an essential quality needed for the production environments of animation-based sketching. While it may be subject to both hardware and software limitations, the principle stands as an important factor in assessing the appropriacy of a given software for animation-based sketching purposes. Furthermore, this is where the dedicated purpose contributions of idAnimate, K-Sketch and Sketch-n-Stretch have the advantage: they were specifically developed to create sketches, and thus they are also suited to live preview. This illustrates the compromise of being limited to one set of animation techniques, which ensures that sketching can happen, but also somewhat limits the sketching capacity.

DESIGNING GRAPHISM AND DESIGNING MOTION

Observation of idAnimate, K-Sketch and Sketch-n-Stretch reveals a pattern in how the content of animation-based sketching is both created and manipulated. Whether hand drawn digitally or imported as graphical elements from other sources, the three types of animation software all separate the design of graphical elements from the design of motion and change. This echoes McLaren's notion of *graphism* (Sifianos 1995), touched upon in part I, as involving something more than deciding upon and manipulating the difference between positions over time. We see this division in play in production environments usable for animation-based sketching - the graphical elements are designed prior to animation and used as *components* in the sketch.

Graphical components

The notion of components or assets is a concept commonly used in both video production, animation and software development (Rosenstand 2002). Regardless of production environment, a component library is invariably featured in made-to-sketch software such as idAnimate, K-Sketch and Sketch-n-Stretch and in general purpose software such as Adobe Premiere and After Effects (figure 56)

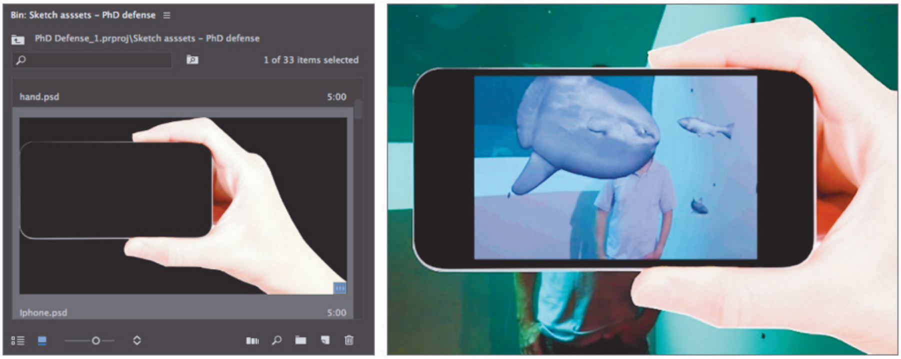


Figure 56: The different graphism components in the production environment (left) applied in specific configured instances in the animation-based sketch (right)

These libraries contain the graphics previously created by capturing material, by designing it digitally or by gathering pre-made material digitally or physically. This is where the variety of graphical materials that can be used for sketching comes into play – for example, the components can be clay, paper drawings, cut outs, puppets, pixelated humans, or digital 2D and 3D content. The production environment for the components might not be digital in the first place, and this is the case when a camera is used to capture hand drawn sketches in various poses for use in stop motion animation.

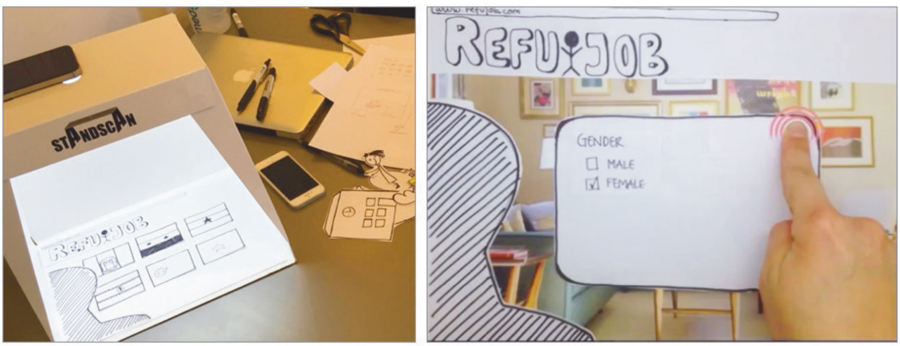


Figure 57: An examples of using cardboard stands to capture frames for stop motion (left) which are later assembled in a timeline as a digital sketch (right)

Sometimes, the production environment itself contains the design tools needed to actually produce graphical elements and then create motion or change (e.g. Adobe Flash and 3D Studio Max). This is also true for the limited material possibilities of idAnimate, K-Sketch and Sketch-n-Stretch. Another core quality of the production environment of animation-based sketching is that it supports either the creation or import of components which can be used in animation. The creation of graphical components thus adheres to the *apprehension principle* of effective graphics: the aesthetics of the components should be conceived in connection to the domain and directed at the functional aspects of *what* information we should gain from watching the graphics at any given moment.

Reusability in the sketching pipeline

It is a major advantage if the production environment further enables the designer to reuse the graphical components over and over in multiple animation-based sketches. For example, the same animated character might be used and animated differently in different user scenario sketches. Some production environments even allow the user to save the configured animations as components in themselves. This makes it faster and easier to reuse temporal information, which can then be assessed in another user scenario, for example, or in a completely different concept. The re-use of either graphics or temporal components is not as essential a quality as the timeline editor or live-preview, but it is still a quality which supports the practical application of animation-based sketching.

Figure 58: Multiple components bein reused in different stop motion sketches - like using the same graphical figures and context, with new technology concepts introduced in each.

We saw an example of this a workshop series with service design students in Copenhagen in 2014 and 2015. Some of the groups of design students focused on reusing the graphical elements produced, and they used Adobe Premiere to save presets for different interface animations, frame by frame movement paths, etc. Instead of constantly recreating the graphics of the sketches, they reused this library to focus their animation-based sketching on generating information about the temporal dynamics of their proposed ideas. These students managed to produce far more animation-based sketches than the other groups in the workshop. Since the sketches were then used to explore more concept ideas than the other groups could manage, this may amount to a strengthening of reflective practice. It also created an effective pipeline of graphical components and animation presets, which became a catalyst enabling animation-based sketching in the group's design process. The important thing to note here is how it is only the idiomatic aspects of the sketches which are reused throughout multiple sketches (e.g. characters, everyday objects, and standard interface components), whereas the non-idiomatic aspects of the proposed concept was the unique element produced for each individual sketch.

One sketch as a component in another sketch

Alongside the multiple different animation materials, tools, digital production environments and pipelines of reusable graphical components is the possibility of *exporting* the animation-based sketch into a playback medium - often separated from the production environment itself. At the instant the sketch leaves the production environment, the animation-based sketch as an emulator of another digital system is essentially complete, since it is now represents a *fixed* emulation of one specific scripted instance of the proposed idea displayed over time. But this may also mean that the entire animation-based sketch is now a design component in its own right, with the potential to be used in other sketches. This is not a dynamic of traditional physical sketching; it is possible due to the digital material. The output sketch can thus be seen as part of an ongoing sketching pipeline. Here, entire sequences are reused in other sketches, which either feature the same interaction or use the original sketch and features in the production environment to manipulate the visual and/or temporal fidelity of the original sketch.

The use of sketches in other sketches often draws on the ability of certain production environments to edit in 'layers'. Here, graphical components can be placed on top of each other in layers which can be manipulated independently and which thus also contain different animated properties. In one layer, an animation-based sketch, from an isolated interface and artifact interaction perspective, may be resized and repositioned to fit in the context of a character in a different layer of the production environment. In this way, layers not only make it possible to arrange different graphical elements in relation to each other, but also to reframe the problem setting of prior sketches entirely. What once was an independent sketch used to generate temporal information for the investigation of an interface might later be reused as an animated component in an explanatory user scenario.

Figure 59: This sketch explored a 'smart garden' concept in which caretakers could control experience stimuli in a care facilities sense graden. The designer had initially explored an animated interface sketch to learn about the interface constraints of such device. Later on the sketch was reused in a user scenario sketch, now placed inside a live action context to explore the contextual setup of the proposed concept.

In this regard, the reuse of sketches in sketching new ideas is subject to the *congruence principle*: changes in the animation should map changes in the conceptual model of the idea. This is so even though reuse distorts the realism of the representation of the idea, as may be the case when using another sketch in a completely different scenario.

Qualities of the production environment for animation-based sketching

As discussed earlier, no production environment can be described as the definitive enabling technology for animation-based sketching. Instead we have proposed a number of quality criteria as critical factors enabling reflective sketching processes in a practical manner: an interactive timeline, live-preview, a graphical component library, the reuse of components, and the reuse of entire sketches in new environments. Even if one piece of animation software does not support all of these criteria, this does not mean that it cannot be used for animation-based sketching. One piece of software might be utilised to enable a specific animation technique with a specific material and later be combined with other techniques and materials in another piece of software. Hence, the practical ability to apply animation-based sketching as a design approach does not solely depend on mastering a specific set of software environment; it involves knowing how to use specific features in different software packages for sketching purposes. Some of these products might be dedicated purpose software, such as idAnimate, K-Sketch and Sketch-n-Stretch, while much of it might be general purpose or specialised software which meets some or all of the quality criteria discussed. Thus, animation-based sketching is enabled by any production environment, as long as it enables the designer to engage in a reflective conversation with the design material and to sketch temporal information about possible future states of the non-idiomatic design situation.

CRITERIA FOR THE PRODUCTION ENVIRONMENT:

An ***interactive timeline,*** or a control mechanism akin to timeline controls, enables iterative back and forth exploration in the designer's use of animation-based sketching

Live Preview of the animation-based sketch establishes the reflective practice of sketching, where the designer constantly acquires temporal feedback from her temporal sketching with animation.

A ***component library*** either creates or imports graphical components to be used in the designed motion or change, thus creating the graphism of animation

Reusable components and animations: the component library is used to save configurations of both graphics and animation to be reused in other sketches. This establishes a more efficient pipeline for sketching, making the process more practical and facilitating the generation of more information

Sketches in layers of other sketches*:* entire animation-based sketches as output emulators are used in multilayer edits with a new animation-based sketch to function in a pipeline as entire sketched sequences

The next question concerns how practical and approachable these criteria are for designers with no experience of animation or digital sketching. In the following chapter, we present some lessons learned from experiments involving the introduction of animation-based sketching to designers in different setups.

CHAPTER 10
MAKING ANIMATION-BASED SKETCHES

This chapter concerns the practical feasibility of using animation-based sketching to explore non-idiomatic technologies in design processes. We present a range of examples of different visual fidelities of animation-based sketching and discuss the difference between visual and conceptual fidelity in the generation of temporal information to reduce uncertainty. Furthermore we investigate the competencies required for designers to apply the approach.

The experiments indicated that animation ties the dynamic temporal information into a narrative and to the context of the proposed idea. By the use of simple animation approaches, sketching time was reduced and more branches of ideas were generated in less time. The participants used simple animation-based sketches to discuss and communicate their ideas, identifying the most promising potential user experiences, and went on to sketch proposals for the more fine grained interactions in their ideas. We further suggest that it is not the fidelity of the visuals or animations which matter the most in animation-based sketching. What matters is the way in which the animated graphics are used to make an idea understandable and relatable so that the designer and other stakeholders can reflect upon the potential user experiences made available by the ideas proposed.

Finally, on the basis of experiments which constrain the time available to produce animation-based sketches, we suggest that the approach is also applicable in constrained design processes where resources are more limited than in experimental design workshops in academia. However, this applicability is constrained when too much emphasis is given to making the sketch adhere to the animation principles of orthodox realistic physics. Animating orthodox physics is counter-productive in the early phases of the design process. If the temporal fidelity required to answer a question needs to include complex physics, the designer is no longer sketching; she has actually begun prototyping.

WHAT DOES IT REQUIRE TO SKETCH WITH ANIMATION?

In part I of the book, we posed the following two questions:

Is animation at all suitable outside big budget future visions? and if it is suitable, ***how can we appropriate animation to explore future scenarios with non-idiomatic technologies without spending more resources than it would take to build a functional prototype?***

We discussed these questions in terms of defining animation-based sketching and, in comparison with static sketching and prototypes, in terms of what the applicability and purpose of animation-based sketching might contribute to design processes. In the previous chapter, we discussed the quality criteria production environments must meet to act as enabling technologies for animation-based sketching. These considerations have given us an idea about the features needed for sketching, and we have seen that designers need to use different software environments in order to fully employ animation as a sketching capacity.

However, we still need to reflect upon the actual application of animation-based sketching as an approach for designers in praxis. In the course of the research project leading to this book, we conducted a series of design experiments which explored different aspects of the practical application of animation-based sketching. In creating these experimental setups, three core concepts had to be balanced: the design knowledge generated through sketching, the sketching process itself, and the specific animation techniques. We might seek to evaluate the quality of the temporal information, which would be different from evaluating the sketching process itself, which in turn would be very different from evaluating the practicality of different animation techniques.

EXPERIMENT 1: INVESTIGATING USER EXPERIENCES

This experiment was part of a research collaboration reported in Vistisen & Poulsen (2015). We conducted the experiment to sample a substantial number of animation-based sketches in a praxis-oriented design process. To create a substantial base of animation-based sketches, we facilitated the U-CrAc yearly workshop. U-CrAc is the abbreviation for 'User Driven Creative Academy'. A total of 36 design-oriented cases from the private and public sectors were included. These cases were given to multidisciplinary groups of design students from interaction design, experience design, industrial design, entrepreneurship design, and cultural service design. A total of 203 students participated. However, 79% af the students had limited experience with video and animation or none at all, and 48% had limited experience of traditional sketching and prototyping. We therefore argue that the majority of participating students could be characterised as *novices* (Dreyfuss & Dreyfuss 1980). The students provided a basis for experimenting with the introduction of animation-based sketching to others, and an examination of whether the approach was viable in the short workshop context. The large number of students and stakeholders ensured breadth in the sketches produced.

Do animation-based sketching support user experience design?

Our research aim was to examine how the proposed design ideas were portrayed as diegetic elements in the animation-based sketches that were produced, and to compare these with the applied animation approach.

The evaluative criteria for assessment of the sketches were based on the broad definition of a 'product' by design researcher Richard Buchanan (2001). Buchanan suggests that, in its broadest sense, the user experience of a product can be understood as the synthesis of three factors: *the aesthetic (desirability)*, *the usefulness (utility)*, and the *user friendliness (usability)* (Buchanan 2001). According to Buchanan, it is the way in which these three factors are combined that distinguishes one product from another. This is true regardless of whether it is a concrete thing such as a smartphone application on a phone or an abstract concept such as a service or policy. Buchanan only implicitly mentions the role of the *use context*, which most design discourses emphasise as a crucial factor in assessing the experiential value of a design product (Hassensahl & Tractinsky 2006, Jensen 2013). We included the contextual integration and representation of the touch points among the evaluative criteria for the sketches

Sampling animation-based sketches

To record the sketches, we instructed the students to use a web-platform (www.urac.dk) as a modified type of technology probe (Hutchinson et al 2003) to gather sketches at different stages of the workshop proceedings.

Figure 60: The U-CrAc web-platform - acting as a technology probe for the design students sketches.

The design students were ask to categorise the animation-based sketches they produced in relation to the sketches produced during the initial period of ideation and the ones produced during a final period of synthesis. This was done in an attempt to separate the sketches aimed at investigation and exploration in the ideation phase from the more explanatory and persuasive sketches in the synthesis phase.

After sampling all the produced sketches, we watched all 158 produced animation-based sketches, and developed a qualitative categorisation based on which of the four user experience aspects (utility, usability, desirability, or context) was present in the sketch. We crossed this with a mapping of the techniques or combinations of techniques that were applied in each sketch produced (figure 61).

GROUP 4 - AskCody	VIDEO	STOP MOTION	ANIMATIC	PURE KEY FRAMES	MOTION OVERLAYS	3D ANIMATION	PRE-MADE	UTILLITY	USABILITY	AESTHETICS	CONTEXT	NARRATIVE
Sketch 1		x						x	o		x	x
Sketch 2		x						o		o	x	x
Sketch 3		x						o			o	o
Final Sketch	x		x		x			x	x	o	o	x
GROUP 5 - LandShape	**VIDEO**	**STOP MOTION**	**ANIMATIC**	**PURE KEY FRAMES**	**MOTION OVERLAYS**	**3D ANIMATION**	**PRE-MADE**	**UTILLITY**	**USABILITY**	**AESTHETICS**	**CONTEXT**	**NARRATIVE**
Sketch 1	x	x			x						o	o
Sketch 2		x									o	o
Sketch 3		x						o			o	o
Sketch 4	x		x				x	o		x	x	o
Final Sketch		x						x		o	x	o
GROUP 6 - LandShape	**VIDEO**	**STOP MOTION**	**ANIMATIC**	**PURE KEY FRAMES**	**MOTION OVERLAYS**	**3D ANIMATION**	**PRE-MADE**	**UTILLITY**	**USABILITY**	**AESTHETICS**	**CONTEXT**	**NARRATIVE**
Sketch 1		x							o			x
Sketch 2			x			x		o	x		o	x
Final Sketch	x				x			x	o	o	x	x
GROUP 7 - HjørringLIVE	**VIDEO**	**STOP MOTION**	**ANIMATIC**	**PURE KEY FRAMES**	**MOTION OVERLAYS**	**3D ANIMATION**	**PRE-MADE**	**UTILLITY**	**USABILITY**	**AESTHETICS**	**CONTEXT**	**NARRATIVE**
Sketch 1 - ikke tilgængelig												
Sketch 2		x					x	x		x	o	o
Sketch 3				x			x	x	x	x		o
Final Sketch	x			x			x	x	x	x	o	x

Figure 61: Our mapping of different animation techniques applied in the sketches, crossed with the user experience factors expressed in the sketches.

The original hypothesis was that we would be able to see a clear correlation between the use of animation techniques offering high visual and/or temporal fidelity, and the expression of user experience aspects. However, the results were not as expected.

No link between fidelity and portrayal of user experience aspects

In the results of our earlier experiment (Vistisen & Bolvig 2015), a comparison of the sketches indicated no clear link between the choice of animation approach and the resulting expression of the user experience of the non-idiomatic technology. This was surprising, since it also seemed to indicate that our discussion of fidelity in animation-based sketches might not be dependent on whether the visual or temporal fidelity was high or low.

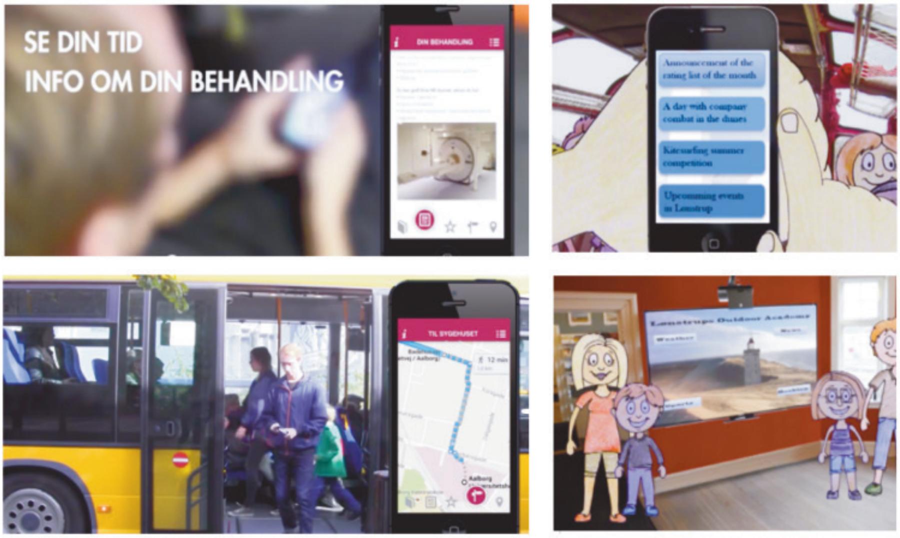


Figure 62: Wether using high visual and temporal fidelity (left) og lower fidelities (right) we saw no clear correspondence between the applied visual or temporal fidelity, and the expression of user experience aspects.

However, if we turn back to our distinction between sketching and prototypes as the difference between generating information about design possibilities on the one hand and reducing the amount of information on the other, it actually does make sense. When generating information through sketching, the designer seeks to reduce uncertainty about the design possibilities. With animation, the designer further gains the ability to generate temporal information about non-idiomatic technologies where few conventions or idioms can provide information about the potential dynamics of the technology. The important thing here is that the focus is on generating information in a problem setting which lacked information before sketching started - a negative measure of information. Thus, the fidelity of the temporal or visual information generated matters less than the fact that information was generated about the questions posed in the problem setting (e.g., how would a given technology behave if the user interacted with it in a certain way, in a certain context). Once the information has been generated, the designer needs to reduce the complexity of the question regarding which of the proposed pieces of design knowledge is the best way to solve the problem. Here the designer needs to be more specific, so prototyping approaches are deployed to test which information is best, that is, most useful, most usable and most desirable. Here, visual and temporal fidelity matters, since the prototype has to be tested and assessed as a limited functional version of something that is potentially 'final'.

LESSON LEARNED:

In animation-based sketching, it is ***not the fidelity of the visuals*** or animations which matter most in the expression of user experience aspects.

What matters is how the animated graphics are used to make an idea understandable and relatable by facilitating reflection among designers and other stakeholders about the potential user experiences in the proposed ideas.

Animation ties the diegetic prototype to the narrative

The sampled sketches from the workshop included examples of more or less all the perspectives, narrative discourses, intents and fidelities that we have categorised as anatomical features of animation-based sketches. Moreover, the sketches categorised as having explored most user experience aspects of the non-idiomatic design situation all had a clear representation of narrative. The sketches in which interaction with a technology was shown without any narrative structure to indicate what came before or what happened to the user afterwards were considerably harder to *read*. Even the sketches which mainly used an isolated interface & artifact interactions perspective could imply a narrative through the use of either narration or user dialogue or through the use of animation to zoom in and out of the interactions in focus.

The overall narrative in these animation-based sketches could be categorised as adhering to a 'finite dramaturgy' (Nielsen 1988) which uses the principles of classic Aristotelean poetics: a *beginning, a middle* and *an end*. In a finite dramaturgy, there is a high degree of causality between scenes, which builds up tension and interest in the scenario. In various configurations, this is often portrayed in a range of sub-elements such as the *teaser, the point of no return, the climax and the resolution* (Vogler 1998, Harms-Larsen 2003).

We used Harms-Larsen's narrative model (2003) to map out the sketches that we had identified as having a clear narrative and mapped how the classical dramaturgy provided a rather close fit to the structure of the animation-based sketches, regardless of perspective, discourse, intent and fidelities. The problem setting is teased quickly and elaborated by showing the context or hinting at it before commitment to the proposed idea at the sketch point of no return. Subsequently, the details of the idea are introduced in an escalation towards the sketch climax, which reveals how the problem is resolved by using the proposed idea before the resolution illustrates the effects on the user experience:

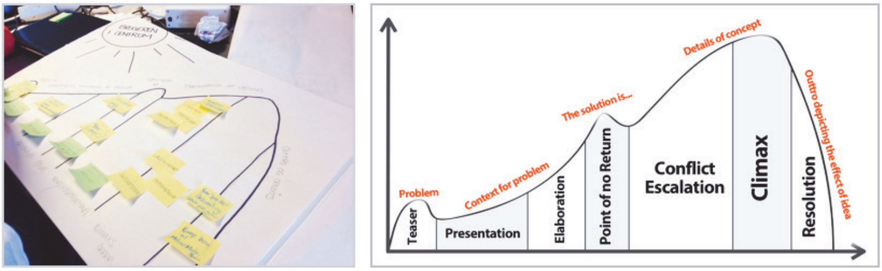


Figure 63: The narrative structure as presented by Harms-Larsen (2003) with escalating tension, towards a climix, the a following resolution.

Consequently, we suggest that the generation of the most articulated design knowledge about the user experience aspects was actually due to following a narrative structure, and thus grounding the proposed idea in a causality which made perception and reflection easier.

It is important to note that the effect of the finite dramaturgy on the ability of these animation-based sketches to express user experience does not imply anything about the quality of the idea itself. The utility, usability, desirability and contextual fit of the proposed idea is not inherent in the structure of the narrative, but rather in the way the non-idiomatic technology is tied into the narrative as a diegetic element. This is where animation makes its main contribution to the sketches. Scenarios, storyboards and other static methods also use dramaturgy as their foundation, but unlike animation-based sketches, they do not tie the dynamics of the proposed design into this story and its context; they represent states and idioms and count on our ability 'to fill in the blanks'.

Through the design of apparent motion and change and thus the generation of temporal information about the non-idiomatic technology as an actant in the narrative, the potential of the idea is illustrated without dependence on the use of established idioms. Novel interactions and use cases can be emulated freely and tied into the context of the narrative. In theory, a static depiction could include all the visual content of an animation-based sketch, drawing out every single frame into one long series of static images. In this manner, all the content would be the same, but something would still be lacking - the temporality itself. When events unfold over time, they have pace and rhythm, which creates anticipation in perceivers (Wells 1998, Block 2007). That is what temporal information consists of: the information which is not inherent in the visual content but in the temporality of the interaction between the visual elements.

LESSON LEARNED:

Through animation, non-idiomatic technology receives temporal feedback - information which could not be generated without ***expression of the dynamics as a sequence.***

Animation ***ties the dynamic temporal information into the narrative*** and context, while remaining a sketch in terms of being a proposal that is framed in a certain way to show certain aspects and to omit others.

Starting simple generated the most detailed design knowledge

While we did not see any correlation between animation technique and the ability to express user experience aspects in the individual sketches, we did subsequently identify a pattern when examining the totality of sketches produced during the design students' sketching process. The 158 sketches were divided into approximately five sketches from each of the 36 groups, and they presented a clear picture of *when* certain animation approaches were applied. In 25 out of 36 groups, the design students' first animation-based sketches used forms of stop motion animation (frame by frame recording) or simple animatics (static storyboard images in a temporal sequence) to express their ideas. These two techniques are radically simpler to apply than other techniques, such as working with key framed animations with graphical components in Adobe Premiere, for example. This pattern could indicate a variation on the classical design tendency of starting in low fidelity renderings and later building higher and higher fidelity renderings (Walker et al 2002, Sefelin et al 2003). Another explanation could be that being novices in the use of animation, the design students chose to start with a technique which required less skill and with which it was easier to get results.

However, an alternative explanation might be that the stop motion and animatic approaches were sufficient for the initial investigative and explorative intent behind the animation-based sketching. Simple stop motion sketches with cut out paper drawings or with arranged objects such as LEGO bricks provide an impressive amount of temporal feedback in relation to their visual fidelity and the relative low time cost of making these often crude animation-based sketches:

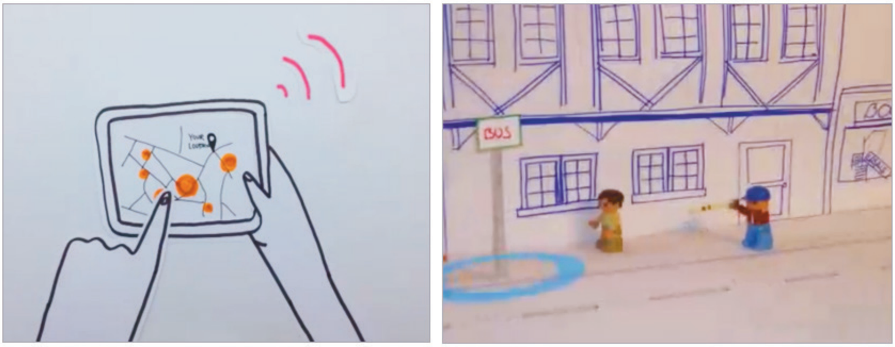


Figure 64: The simple animation techniques, such as stop motion with cutouts (left) or LEGO bricks (right) provide a surprisingly high level of feedback on the user experience of a concept, without taking up much production time. See the sketches at https://goo.gl/RZ6MSc and https://goo.gl/q2WOj9

This supports the earlier point: low visual and temporal fidelity are sufficient in the early sketches. Even with low fidelity, the generation of temporal information provides feedback about dynamics, interactions and user experience in the user context, thus providing information about the uncertain non-idiomatic aspects of the proposed ideas. Essentially, none of these early and crude animation-based sketches represent the proposed technology in a realistic sense; they are highly distorted. Instead they represent the underlying conceptual model of the proposed idea, creating a superficial understanding of the potential of the idea. This understanding is open for reflection and re-interpretation within the frame of reference of the representation. This shows how the congruence principle comes into play in these early animation-based sketches. The sketch distorts realism to leave gaps for further questions, while providing enough visual and temporal information to allow an understanding of the overall synthesis of utility, usability and desirability in the use context. Here the apprehension principle comes into play, as the graphism of the animation-based sketches follows the conventional graphic representation in the specific domains and is stripped of cosmetic features that are not directly useful for understanding. We argue that it is the combined workings of the congruence and apprehension principles that make the early rough animation-based sketches work. Apprehensible idioms are used for the aspects of the sketch which should not be questioned - for example, the representation of the user through a hand drawn figure or a LEGO figure. Non-idiomatic aspects such as the interaction design of the proposed idea are thus brought into focus by simplification or distortion so that the attention-guiding principle can guide the viewer to see exactly which aspects of the idea are novel and interesting. Thus, the simple nature of the animation-based sketches actually supports an understanding of the important non-idiomatic aspects in the sketch by emphasising what to question and what to take for granted.

This application of the apprehension, congruence and attention-guiding principles to animation-based sketches also links back to the previous point about the role of narratives. Ulla Ryum (1983) argued that the role of the designer of dramaturgy was to stage the frames within which the audience would be able to perceive a narrative. The designer's aim is to get the audience to accept the conditions of this particular narrative structure and to guide them towards the points in the narrative at which the audience should think about the narrative and criticise or appreciate it . In conjunction with the three principles for facilitative animation, the finite dramaturgy thus reduces the interpretive space by framing the problem setting as part of the problem-solving proposal of the sketch. The reduced interpretive space of the narrative which this produces is essentially equal to the reduced uncertainty of the design process. Reflections upon the proposed design idea can occur in the interpretive space, adding to the total sum of information about the potential of the idea.

So, the tendency to start with simple animation was evident in 25 of the animation-based sketches from the workshop. 16 of these projects continued to use the techniques in their later synthesis sketches, where what was a predominantly investigative and explorative intent had changed to one that was more explanatory and persuasive. However, 19 of the projects, also experimented with other, more sophisticated animation approaches for their later sketches, often in combination with the simpler methods. Methods such as the use of key-framed animation, the application of motion graphic layers on top of live video, with and without green screen, and the use of 3D animation are all to be found in these animation-based sketches.

Some of the sketches used these more sophisticated animation approaches to investigate and explore more complex visuospatial concepts whose temporal dynamics cannot be expressed through simple cutout stop motion or animatics. This can occur, for example, when the designer explores a new interaction design based on gestures, in which the interplay of animated components and live footage is needed to express the user experience.

Figure 65: This sketch explores smart TV solution for elderly people, which uses the traditional remote control as a gesture-based controller. The sync between the live actors movement, and the response on the television was created with keyframed animations timed with the actors motion, and thus had a higher temporal fidelity than what e.g. stop motion could have provided. See the sketch at http://goo.gl/4hm6nd

Despite the higher complexity of the animation approach and the longer sketching time spent in their creation, these sketches still expressed both investigative and explorative sketching intents in the exploration of new ideas, and they generated new temporal information about the dynamics of the technology involved. This was so even though many of these sketches were also later used as communicative vehicles outside the team of design students.

Another type of more complex animation-based sketch involved the remediation of existing ideas from previous sketches to create refined versions of the investigative and explorative sketches with a more explanatory and persuasive intent. On the surface, these sketches essentially only looked like sketches, but were part of a sketching process, since the idea had already been conceived in a previous sketch. In many instances, the representation in a new visual and temporal fidelity also established a new interpretive space for the narrative. Even though the basic nature of the idea was the same, the conceptual model changed because the new representation changed the visual and temporal feedback, thus reframing the problem setting. What might superficially appear to be just a higher fidelity rendering of an existing idea is essentially a new idea in its own rights, due to the new information generated. This in turn shows why these sketches might both be used for explanatory and persuasive purposes while having an investigative and explorative function in the sketching process itself.

While we saw a significant pattern in sketches which progressed from initial simple animation-based sketches to more complex sketches, a few also started with complex sketching approaches. However, in terms of their ability to express user experience aspects of the non-idiomatic technology used, these sketches actually generated less relevant information. While one sketch might express the utility, usability and desirability of the proposed technology, the totality of the sketches produced showed far fewer ideas, or only small variations of the original idea. In contrast with the cases which started simple and used more complex animation later, it seems that the use of complex sketching approaches at an early stage leads to the initial idea taking hold. This corresponds well with the established notions in both sketching and prototyping that high fidelity tends to make the initial idea 'stick' (Buxton 2012, Greenberg et al 2012).

This experiment indicates that in animation-based sketches too, overly complex visual and temporal fidelity may restrict the interpretative space for understanding the interactions and the user experience of the technology in the user scenario. As a consequence, far fewer ideas are generated and less information is available to reduce the uncertainty of the non-idiomatic aspects in the design process. Of course, fewer ideas might still lead to a relevant solution - the idea *might* be good enough. But adopting Buxton's notion of 'inertia in innovation' (Buxton 2010, 39), we can see that the designer runs the risk of making an uninformed decision, which in turn will increase the risk that the solution will not match the preferred state.

LESSON LEARNED:

The ***simple nature*** of animation-based sketches actually promotes understanding of the important non-idiomatic aspects of the sketch by emphasising what to question and what to take for granted.

Overly complex visual and temporal fidelity run the risk of creating an interpretative space that is too narrow to promote understanding of the interactions and user experience of the technology in the user scenario.

To a considerable extent, novice design students were able to adopt animation-based sketching as a design approach in just two weeks. When the basic method, principles, techniques and theory had been introduced, the students went on to explore a multitude of software and hardware production environments in their sketching. However, we only took this to mean that it was *possible* to use animation to sketch interactions and represent user experience aspects of non-idiomatic technologies, but not necessarily that it was *practical*. To test its practical applicability, we needed to evaluate whether the approach could be taught and applied in days rather than weeks.

EXPERIMENT 2: FROM INTRODUCTION TO SKETCH

We constructed the second experiment to resemble the setup from the U-CrAc workshop and thus create a basis for a comparison of sketching input with time as a variable. A five day workshop was held for a small group of 25 service design students in Copenhagen in 2015. The participants had the same novice experience in animation and sketching as participants in the U-CrAc workshop.

We introduced the same amount of methodological and theoretical material as provided in the U-CrAc workshop and provided the same lecture material. In the U-CrAc workshop, the students had a total of 5 days for ideation and 4 days for synthesis. In the Copenhagen workshop, however, we limited ideation to 2 days, and synthesis to just 1 day. The students were given one day of lectures and hands-on training with production environments such as iStopMotion (boinx.com) and Adobe Premiere Pro (adobe.com), and with the same animation approaches as in the U-CrAc Workshop. Thus, the conditions for adapting animation-based sketching were radically tightened to challenge the viability of animation-based sketching as a practical design approach rather than an academically interesting use of animation.

Our hypothesis was that the approach could be deemed viable in practice if, following a one-day introduction to animation-based sketching, the design students could investigate and explore user experience design ideas after only three days, finally merging them into an explanative and persuasive sketch.

Animatics representing scenarios of non-idiomatic interaction

Prior to the workshop, the design students had already carried out interviews and ethnographic field observation in their respective user contexts. All students were already practiced in discussing different design ideas and problem settings when they were introduced to animation-based sketching. While many discussions had occurred, however, none of the ideas had really materialised, and few of the discussions had focused to any notable extent on utility, usability, desirability or context. We asked the design students to orient these loose ideas towards actual representations of the proposed technology in the use context by integrating their ideas into *scenarios of interaction* (Caroll 2000). The response to this instruction revealed a pattern that was similar to the one observed in the U-CrAc workshop: the majority of design students began sketching their ideas with simple stop motion or even simpler animatics.

The main difference her, however, was that the simple and fast animatic technique was far more frequently used in the initial ideation phase than it was in the U-CrAc workshop. From a practical point of view, this seems natural, due to the limited time available and the need to sketch many diverging ideas. This raises an important question: does an animatic which does not create the illusion of apparent motion in the sketched state contain enough temporal information to inform the design process? In theory, these animatics do not include more information than they would if portrayed in static sketches storyboard scenarios. But when we consider that the temporality of sequences of events over time has pacing and rhythm, extra information is added to what would otherwise only be static. Although the animatic does not generate much information about the specifics of the interaction, it serves to anchor the proposed technology to the context. The pacing and rhythm of the animatic creates anticipation in the viewers and thus also opens up the interpretative space of the sketched narrative as they begin to reflect upon *what will happen next* (Wells 1998, Block 2007). Thus, although the non-idiomatic technology itself is still only portrayed in static images, the reflections about the dynamics are supported by the temporality of experiencing the narrative as a sequence over time.

Figure 66: Two examples of animation-based sketching using animatics, in which little or no motion is essentially animated, but rather just adding timed sequentiality to static sketches. See examples of these sketches at https://goo.gl/TvKhJ1 and https://goo.gl/KL3X3w

It is also evident that animatics do not enable the same temporal feedback as the other possible uses of animation: this is probably because animatics have very low temporal fidelity. It was also evident from the students' animatic sketches that the interpretive space might have been too wide, given the possible interpretations of the potentialities of the concepts proposed in the narrative. While design sketching in the early phases of design should be ambiguous and open for further reflections, too much ambiguity prevents a reduction of uncertainty about the details of the possibilities within a non-idiomatic design context. The initial animatic sketches created by the participants did not provide sufficient support for exploration of the non-idiomatic interactions and dynamics of the technology itself.

What the sketches did, however, was to support the exploration of the non-idiomatic design context where the finer grained interactions of the applied technologies would take place. In this way, animatics creates a sketching process of divergent design thinking heralded by Buxton (2010, 338).

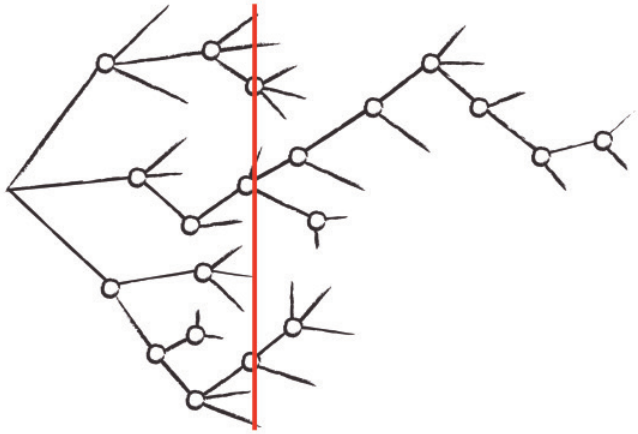


Figure 67: Buxton's depiction of the divergent branching of concepts through sketching.

Buxton argued that branching explorations should avoid the inertia of innovation by initially exploring multiple branches rather than just incrementally working down one idea branch. The rapid creation of animatics enabled the students to explore many ideas in one day, while also getting temporal feedback about the dynamics, although the temporal fidelity was low. The branching nature of the students' ideas was shown in the variety of concepts explored in each of the groups: the number explored in just a short time was actually higher than the number of ideas the groups in the U-CrAc workshop produced in five days.

LESSON LEARNED:

By using simple animation approaches, ***sketching time is reduced*** and more branches of ideas are thus generated in less time.

Simple animatics can be used to investigate problem settings and explore future scenarios, identifying the most promising potential user experiences to be further explored by the application of finer-grained techniques.

Fast transition from low to high temporal information

As was the case in the U-CrAc workshop, when the design students began exploring the different interaction design possibilities within their design context, most of them adopted more complex animation techniques. In contrast with some of the U-CrAc cases, however, here there were few examples of complex animation approaches being applied to generate entirely new branches of ideas. Instead, observations from this workshop showed that the higher visual and temporal fidelity of the complex animation approaches was invariably used to extend, elaborate and combine user experience aspects from the previous sketches. One sketch, for example, used the static sketches from the animatics and added more dynamics to both the user context and the interaction with the proposed digital application, a mobile game in sync with a crowdfunding platform.

Figure 68: The static images from the animatic (top) were later reused and reworked with more temporal information in a later animation-based sketch, with keyframed motion to better illustrate the game elements of the proposed crowd-funding game (bottom). See the animatic at https://goo.gl/Q2FyEG and the final sketch at https://goo.gl/EmSpZV

The basic graphics of the two animation-based sketches are the same, but the later sketch has added higher temporal fidelity to the interaction with the mobile game and a distorted expression of crowd-funded cash flow to show the conceptual model of the sync between game and crowd funding. The choice of this specific branch of their ideation and the use of animation to explore the dynamics of the interaction with the digital service reduced uncertainty about the non-idiomatic aspects of the design possibilities of this type of game. During the last day of the workshop, the animation-based sketch was further used in a design critique session (Buxton, 2010), in which the group was challenged with new questions about the details of how the specific idea might be realised. The questions added to the complexity of what was already an uncertain situation, marking the students' transition to developing testable prototypes of variants of the game in the weeks following the workshop.

A plausible approach in praxis?

The group took only three work days to produce the initial five animatics, the three extrapolations of these ideas, and the final synthesis of their proposed solution. The same productivity was evident in the other four groups participating in the workshops, with small variations in the number of early animatic sketches (4-7). We argue that the results from this workshop indicate that the benefits of animation-based sketching with its multiple different approaches and production environments can also be achieved in shorter design sprints than seen in the U-CrAc workshop.

LESSON LEARNED:

As a design approach animation-based sketching is also potentially applicable in constrained design processes in which ***resources are more limited*** than in experimental design workshops in academia.

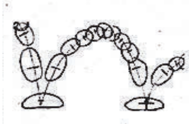
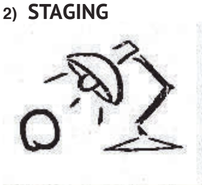
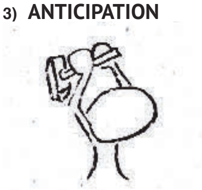
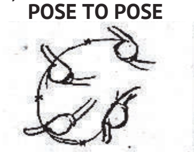
SKETCHING BACK TO SIMPLER TIMES

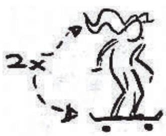
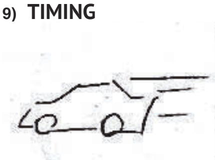
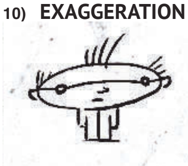
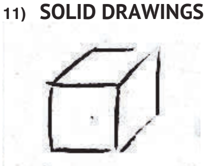
In re-examining the animation-based sketches sampled for use in this book, we noticed a rather intriguing pattern in the animation techniques commonly used in animation-based sketching. The majority of the investigative and explorative approaches did not do much to follow the orthodox principles of animation, such as Disney's 12 animation principles (Thomas & Johnson 1981). This was also largely true of the explanatory and persuasive approaches. As we have seen in our examples, the archetypical animation-based sketch uses varying visual and temporal fidelities to communicate the underlying conceptual model of the idea it proposes and does not necessarily seeks to do so in the most factual or detailed way possible. Instead, the animation-based sketch leapfrogs many of the animation practices which would traditionally take a considerable amount of time to get right. This ensures that the appearance is still sketch-like while saving time and thus making it viable to sketch with animation.

This corresponds with our previous observation that the heritage of Disney's hyperrealism is that an animated sketch will always portray a 'second-order realism'. Animated sketches must address the ontological laws of reality, but they need not necessarily prioritise a strict adherence to the orthodox movements and physical aspects of objects. We hypothesise that animation-based sketches do not need to refine their creation of motion on the basis of the 12 animation principles of 'the illusion of life', but might actually achieve their sketching goal by adopting the earlier principles of animation.

The 12 principles of animation in animation-based sketching

In relation to our sampling of animation-based sketches, and the examples we have presented so far, we will now revisit the overview of the 12 principles of animation, but now examining their inclusion in design sketching – or their exclusion (next page).

1) **SQUASH & STRETCH** 	This principle is based on either following or distorting the material properties of the object animated, which is a level of material detail rarely considered in animation-based sketches. Squash and stretch is only used to the extent that the sketch needs to make a point about how the rigidity of something in the scenario is affected.
2) **STAGING** 	Staging is similar to what we have previously discussed in relation to the attention-guiding principle (Betrancourt in Mayer 2005) in animation-based learning. Therefore, staging can be seen in almost any animation-based sketch, regardless of the perspective of the sketch, although user scenario perspectives are arguably more clearly staging events than isolated interface & artifact interactions alone.
3) **ANTICIPATION** 	Anticipation in animation-based sketches occurs mostly in sketches that apply more complex animation approaches. The often higher temporal fidelity of the sketch makes it easier to focus on what will happen. In the simpler sketches, for instance using crude stop motion with paper cut outs, anticipation is harder to achieve due to the jagged motion and the lack of enough drawn elements to clearly demonstrate the upcoming change in the details of the sketch.
4) **STRAIGHT AHEAD & POSE TO POSE** 	Straight ahead motion is techniques often seen in stop motion and animatics, in which animation is done continuously, while keyframed pose to pose is typically applied when digital production environments are used to interpolate between different configured positions.
5) **FOLLOW THROUGH & OVERLAPPING** 	This combination of principles is rarely seen in animation-based sketches, due to the careful details of tweaking the animation to adhere to the orthodox motion of synchronous motion and overlapping motion.
6) **SLOW IN & SLOW OUT** 	Again, due to its reliance on the creation of orthodox motion or change that replicates aspects of realistic or exaggerated physics, this principle is also somewhat rare in animation-based sketches. The principle may come to expression as specialised pre-defined functionality in some production environments that suit sketching; here, crude interpolations of slow in and slow out may be used in sketching.

7) **ARCS** 	In the orthodox sense, arcs are absent from animation-based sketching due to the rigidity of tweaking motion paths to follow realistic arcs. To make the animation process faster, many of the animation-based sketches observed use straight lines, rather than arcs, to follow more mechanical movement arcs.
8) **SECONDARY ACTION** 	This is akin to the apprehension principle (Betrancourt in Mayer 2005) in animation-based learning, which is also followed in much animation-based sketching. Visual and temporal fidelity should only be emphasised to the point of portraying essential qualities in the idea, without the addition of details which do not address the problem setting or guide the perception away from it.
9) **TIMING** 	This principle takes its cue from the other physics-based principles but addresses the overall sequentiality of the actions animated. Thus, timing always plays a role in determining the pacing and rhythm of an animation-based sketch, but there are limits to how much time the designer can dedicate to creating fluent and emotionally readable timing.
10) **EXAGGERATION** 	Exaggeration can serve both dramatic and comedic purposes and is thus one of the most variable principles of animation. We might argue that the unfinished visual and temporal fidelity of animation-based sketching is in itself a form of exaggeration which distorts the realism of the proposed idea in the representation, making it more open for reflection and re-interpretation.
11) **SOLID DRAWINGS** 	Many of the animation-based sketches we have discussed show little adherence to the three dimensional space per se. This is especially true for simple stop motion techniques. Especially when combined with live action footage, some keyframe based animation uses simple perspectives, for example, to make an interface sketch fit within a given object in the actors' context.
12) **APPEAL** 	Even though the animation-based sketches we have sampled do not all show signs of attention to the creation of a specific appeal, appeal is a potentially important aspect of explanatory and persuasive sketching that can frame apathy, sympathy, empathy or even antipathy for a given user (Vistisen et al 2016).

Half of these principles are based upon the creation of realistic or hyper-realistic physics in animations (Squash & Stretch, Follow-through & Overlapping Action, Slow-in & Slow-out, Arcs, Timing and Solid Drawing). As we mention above, most of these physics-based principles rarely occur in animation-based sketches. This might be due to a lack of animation experience on the part of the design students and designers who created the sketches we sampled. Another explanation might be that even for a skilled animator, it takes a considerable amount of time to make the physics-related principles actually behave in accordance with orthodox physics (Wells 1998, Thomas & Johnson 1981). This would correspond to Chang & Ungar's findings (1993): correctly implementing the animation principles in user interface design requires a significant amount of extra labour. This still rings true now, more than 20 years later, despite the advent of more accessible production environments.

LESSON LEARNED:

When applying animation-based sketching, animating ***orthodox physics*** often becomes counter productive in terms of actually sketching and not just designing an animated output.

If the required temporal fidelity needs to include complex physics, the designer is no longer sketching but has actually ***transcended into prototyping.***

Without adherence to the physics-based principles of animation, representations of simple or naive physics (Sheet-Johnstone 2011) are able to generate information about the overall dynamics of interaction, while complex physics can reduce the complexity of the choices faced by clarifying which dynamics will work best. In essence, this reduction of complexity is prototyping based upon the branches of information about possible interaction designs, and it is more practical and viable in simpler animation. Thus, the 12 principles of orthodox animation are usable in animation-based sketching to the extent that they tell us about staging, anticipation, exaggeration, appeal, the creation of secondary actions, and the variation between straight-ahead or pose-to-pose animation. However, the applicability of the six principles of physics varies, depending on the ability of the production environment to speed up the process and on the extent to which the principle is central to the temporal fidelity needed for the information generated.

Simple animation principles in animation-based sketching

If only six of the 12 principles of orthodox animation are universally seen in animation-based sketches, we should examine other less sophisticated practices of animation to identify simpler animation principles that are applicable to sketching. In describing the process of developing the 12 principles of animation at Disney, Thomas & Johnson (1981) provided a series of examples of the more primitive predecessors of what we now consider modern orthodox animation. These included the *cycles* of animation which animates back into itself, the *repeated actions* of reused animations in multiple scenes, *cross overs* multiplying different animations in different drawings, and the general *rubber like physics* of the movements.

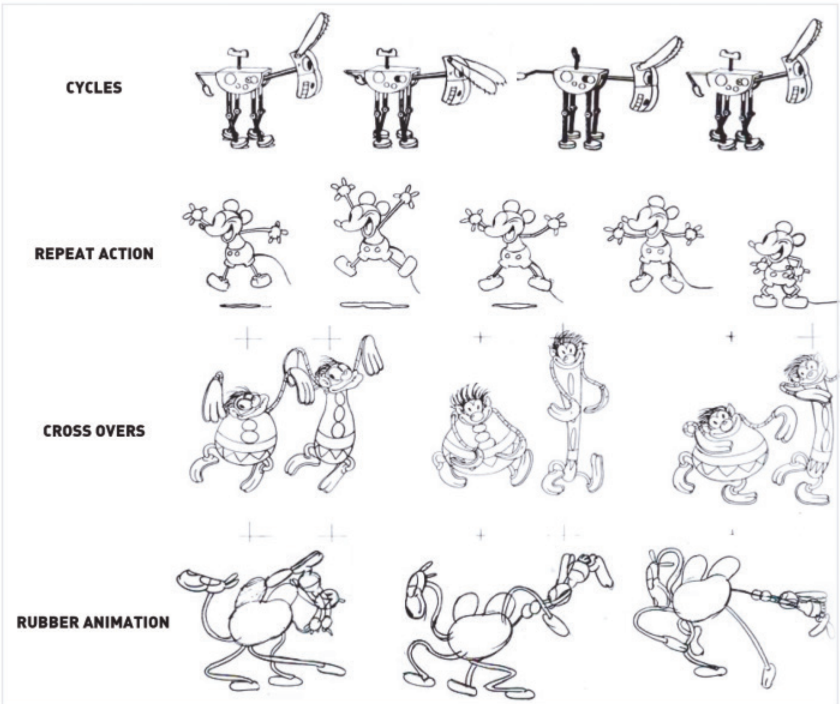


Figure 69: A range of the pre-Disney animation principles, all used to either decrease production time or to accomodate for not adhering to orthodox physics. Sampled from Johnston & Thomas 1995).

These simple techniques were originally born of the necessity to meet the needs of the still infant animated film genre in the 1920s. Disney studios did not have the funding to experiment with the realization of Walt Disney's ambition of hyperrealism (Thomas & Johnson 1981). Thus these techniques simply saved time and production costs by creating apparent motion and change which the audience could still perceive.

When we examine the sketches from the U-CrAc workshop and the Copenhagen workshop, we see that the majority of these sketches actually employ these *good-enough* principles of the pre-Disney era of animation. The physics mostly adhere to a plastic like feel, with little effort put into making character movements fluid or sticking to proportions. In addition, the animated sequences are often run in cycles or repeated at different moments in the sketches to save production time. Furthermore, the same animation presets, digital copies and edits of one interpolated set of motion or change are often employed as cross overs to other objects - again to save production time while sketching.

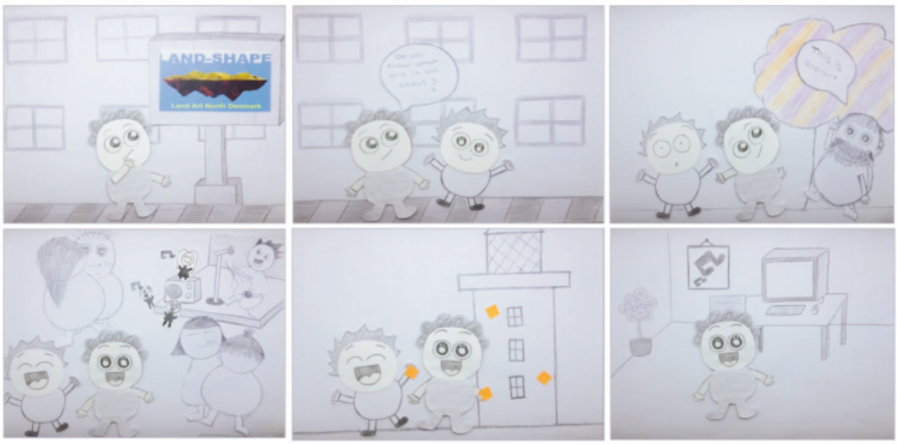


Figure 70: This sketch, exploring a cross media marketing concept for a sustainable festival serves an example of how pre-Disney principles such as cycles, repeated actions and synchronous cross overs are used in animation-based sketches to decrease time spent animating, freeing time to explore more ideas. See the sketch at http://goo.gl/vGN5AK

This indicates that the principles of creating apparent motion or change in animation-based sketches seem to rely more on the simple principles of animation than on orthodox physics and hyper-realism. Of course, animation-based sketching may use all 12 principles of animation to create high temporal fidelity in the graphic components animated. The risk is that this will demand too much production time, be too specific, and be 'too narrow' in reducing uncertainty about the possibilities in a non-idiomatic situation. This echoes much of the previous critique of the use of animation in design sketching (Buxton 2010; Ylirisky & Buur 2007). The use of simple animation principles overcomes much of this criticism.

LESSON LEARNED:

Animation-based sketching can be undertaken as a ***developmental genre*** of animation using the principles of the traditional orthodox and artistic genres of animation - but in a simpler and more eclectic manner.

This again demonstrates the limits of using animation for sketching purposes. When temporal feedback is needed about specific and detailed movements which require adherence to physics-based principles, the amount of time and the animation competencies required do not suit sketching. As we saw from the use of animatics in the workshop cases, the ability to quickly explore multiple ideas branches is crucial to sketching. The simple principles of animation and the adherence to some of the 12 orthodox animation principles define the limits of the expressive capacity of an animation-based sketch. Thus, animation-based sketching is not a universally viable method, but it can contribute to non-idiomatic design situations where temporal information needs to be generated rapidly before a decision can be taken about more specific and complex rendering and production approaches.

CHAPTER 11
THE VALUE IN PRAXIS

On the basis of a series of empirical examples, this chapter shows how animation-based sketching can be applied in praxis to explore design issues concerning non-idiomatic technologies in the early design phases. We attempt to show a range of implementations: our own research through design activities, implementation of the approach in an external company, and an examination of the experiences of companies who have experimented with animation-based sketching.

These lessons learned from practice illustrate the potential advantages and the possible pitfalls of using animation-based sketching in the practice of design. The first case illustrates how animation-based sketching can facilitate decision-making throughout an entire digital design process. This indicates that the role of animation-based sketching need not necessarily be limited to the early phases of design. Furthermore, we see that time and care invested in the creation of animation-based sketches in the design stage might subsequently be recouped in designing the equivalent graphical and temporal aspects in the later development.

The second case shows that the expressive capacity of animation also entails risks. While temporal information is necessary to inform the sketching of the dynamics of non-idiomatic aspects, it also runs the risk of posing too many questions at once. In other words, the information generated raises the level of complexity faster than the level of uncertainty regarding the design possibilities is reduced. This, we argue, is a crucial aspect of animation-based sketching.

To some degree, the industry has already experimented with the use of animation-based sketching approaches, at least as a means of visual communication. This indicates a recognition of the potential of using animation to represent the interaction design and user experience of new digital systems prior to development.

CASE 1: EXPLORING AUGMENTED REALITY IN AN AQUA ZOO

We participated as active constructive design researchers during a year long digital design process at the North Sea Oceanarium. This state-recognised zoo receives an annual subsidy from the Danish Ministry of Culture, supplemented by income from ticket sales and other activities. The aim of the zoo is to inform visitors about the North Sea through edutainment activities. The zoo covers different maritime topics, from underwater biology to sustainable human use of the seas,. The oceanarium displays a wide selection of maritime creatures and plants from the North Sea.

In 2012, as part of the zoo's 2020 strategy, the organisation began to focus on creating digital extensions of the physical experience at the zoo, which led to our involvement in a research-through-design project (Gaver 2012). In this project, we participated in a multidisciplinary design team working on the development of a mobile augmented reality application, the North Sea Movie Maker (Huge Lawn 2013). In mobile augmented reality, a digital layer is superimposed on the real world through a mobile medium in a context. In this regard, augmented reality may be considered an example of a non-idiomatic technology. At the time, augmented reality had not yet been fully commercialised (Höllerer 2004), and it lacked well-established user experience idioms (Mekni & Lemieux 2014, Kloss 2011).

The app that was developed makes use of a novel approach to markerless augmented reality platforms to allow users to record live footage during their visit to the zoo. The footage is manipulated and distorted in real time by the app, while digital special effects are superimposed on the video, generating scenes in which fish and other virtual actors interact with the filmed guests. The video is then saved on the smartphone, and the app subsequently cuts seven short video bits into a one-minute coherent movie with special effects.

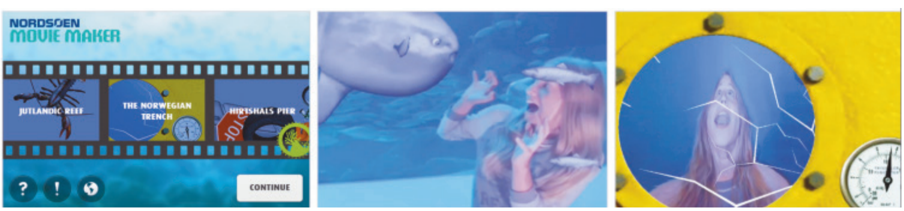


Figure 71: Images from the final 'North Sea Movie Maker' mobile application's interface as well as the augmented reality effects generated.

The application was launched on the iOS App Store in October 2013 and went on to gain award-winning recognition for its innovative blend of new technology and user experience (AAU 2014). We argue that because of the recognized success of the app, it can be viewed as a case example of a non-idiomatic design situation resulting in a viable solution, where the major design decisions were facilitated by the use of animation-based sketching.

Facilitating consensus between stakeholders

The main challenge faced by the project was the need to attain consensus between the multidisciplinary stakeholders in a design team consisting of a biologist, zoo keepers, marketing personnel, interaction designers and developers. We understand consensus as involving a dynamic and iterative group discussion process coordinated by a moderator, who helps experts to approach agreement (Kacprzyk & Fedrizzi 1988). This definition can be further elaborated as a process of cooperative decision-making in "...*finding the best alternative(s) from a set of feasible alternatives according to the preferences of a group of experts*" (Herrera-Viedma et al 2007). In a digital design process, consensus-making can be understood as the generation of a range of possible design alternatives followed by stakeholder evaluation of the information as a way of reducing uncertainty about the scope of the design.

The initial ideation with brainstorming sessions and static papers involved sketching a large number of ideas for creating digital experience design in the zoo context. However, it quickly became evident that the non-idiomatic aspects of many of the ideas were hard to grasp and assess on the basis of the static sketches alone. This particularly affected members of the team such as biologists and zookeepers who did not have domain specific knowledge about digital design. It presented a problem because these team members had invaluable contextual knowledge about the zoo, including how to guide guests in the best way. In discussing this challenge, we realised that the problem arose every time something happened 'between' the depicted states in sketches (Vistisen & Rosenstand, 2016). As a consequence, we introduced animation-based sketching so that we could investigate the temporal dynamics of the concepts, but also as a means of visual communication to facilitate consensus-making in the team.

We applied various animation-based sketching approaches throughout most of the early fuzzy front end of the design process, even after the first interactive coded prototypes were developed. Below we will briefly introduce some of the findings, which are further extrapolated in Vistisen & Rosenstand (2016).

Investigating the form of the augmented reality

Several concepts for the mobile experience took shape in response to the idea of giving the visitors the possibility of shooting short movies with the sea animals superimposed as special effects. This required the initial establishment of the augmented reality content and its aesthetic fit when it was superimposed on the physical context of the zoo. The zoo keepers in the design team argued that for the idea to function as an extension of the physical experience at the zoo, we needed to know the exact extent to which we could go 'over the top' with content before it became a parody of the living creatures in the zoo.

Thus, the design problem was to establish design alternatives: whether to take a 'slapstick' direction or to aim for a more realistic depiction of real sea animals. This presented two issues to be dealt with: the overall look and feel of the content on the one hand, and the interactive behaviour of the content on the other. At this stage, several animation-based sketches were created. The first explored a slapstick aesthetic using simple stop-motion animation: drawn elements were superimposed on a still image of a smartphone pointed towards a guest in the zoo . The stop motion effects were animated using the simple off-the-shelf software 'iStopMotion' (Boinx.com). Each graphical element was placed in the scene, moved frame by frame, and smoothed out by adding motion blur when the final sketch was being processed. Afterwards, we introduced a 3D scan by using the free consumer grade appplication '123D' (autodesk.com) and scanned one of the toys in the zoo, a sunfish. This model was superimposed on top of live footage from the zoo to investigate different ways in which realistic-looking content could augment live video. These sketches were done in just a matter of hours, and while the investigative function took place in the digital production environment, the explorative function was evident in the ensuing discussions between the stakeholders.

Figure 72: The first stop motion animated sketch of the app concept (left), a 3D-scanned model of a sunfish (middle) and the same model with crude textures animated on top of live video to emulate the augmented reality (right). See the sketches at https://goo.gl/3wbfHy and https://goo.gl/9mA0UR

The animation-based sketches allowed the team to actually see a temporal representation of how the two aesthetic genres might affect the zoo's guests. The information generated provided a basis for discussing 'what' the future user could experience. Having seen the sketches, a zoo keeper and a biologist argued strongly in favour of the realistic aesthetic, while the user experience designer and the marketing manager of the zoo argued for the more over-the-top slapstick approach. One party primarily advocated the fact-based learning objectives of the zoo, and the other primarily advocated the experiential and thrill seeking side of the zoo experience. This illustrated a typical consensus issue, in which experts with different perspectives favour different design alternatives entailing widely different courses for the design.

In this situation, we could see how the ability of animation-based sketching to mix the aesthetic and interactive aspects of the content had a mediating effect. We used the discussion which arose from watching the sketches to create a combined perspective. From this point on, it only took a few hours for the team to mix together the elements from the two sketches and create a new animation-based sketch in which the realistic looking animals interacted in slapstick comedic ways with the users in front of the camera. We created this animation-based sketch by using a simple keyframe animated distortion of the live video footage to make it look as though it was being squeezed by the fish model.

Figure 73: The animated sunfish was reused as a keyframed element on top of live action video, in which the video layer itself was keyframe animated to become distorted in the direction of the animated sunfish to how the make the augmented reality content fun and immersive. See the sketch at https://goo.gl/aY7Fyg

When we created this sketch, our investigative intent was to investigate whether it would work if the superimposed augmented reality content distorted the live footage in real time: would it create a humorous effect? Once we had established the setup in the above sketch, the explorative function took over as we involved other stakeholders from the team in the sketching process, watching them respond to the different variations we made in the animations. We expected this sketch to create even more discussion about the mix of genres. On the contrary, since the sea animals performing the actions were realistic, the zoo stakeholders no longer had any reservations about the slap stick humour. This indicated that the conceptual model for the concept had to adhere to orthodox visual fidelity, while the actions and effects could take more artistic liberties. Thus, consensus regarding the content criteria for the design was facilitated through the temporal information generated using animation-based sketches.

Exploring interaction between the mobile app and the users

After establishing consensus regarding the content criteria, the team had to assess how the features of the content could be interacted with - both in terms of user interface design and of the broader set of interaction modalities available in the mobile medium. These questions concerned the non-idiomatic aspects of using augmented reality in the zoo context: *"Should we use fixed markers or marker-less methods? Should the user be able to interact with the augmented overlays? Which elements should be affected by the overlays?"* (Vistisen & Rosenstand 2016)

None of these issues could be discussed in a meaningful way on the basis of the static sketches since they dealt with highly interactive and temporal features, with few best practices or idioms to lean on. Furthermore, the two programmers in the team estimated that using coded prototypes in generating information to inform a decision about these questions would be costly if we ended up not deciding which idea branch the prototype would take.

Using the animated content sketches from earlier, we created a series of sketches in which the content could be evaluated in different interaction designs. We used simple keyframe animation in Adobe Premiere, in which the software interpolated movements between two or more designated key positions. We animated still images of a transparent smartphone superimposed on footage from the zoo and used the content sketches in tandem to illustrate how different types of augmented reality could be controlled and experienced by users.

Figure 74: Sequence from one of the sketches, exploring how the augmented reality effects would become activated on the mobile medium. A still image of a hand holding a smart phone is animated on top of video footage from the zoo, with the animated content sketches placed on top to simulate the augmented reality when the interaction occurs. See the sketch at https://goo.gl/U2UqH9

While sketching, we investigated numerous ways in which the augmented content could be activated. After outputting a series of sketches, the sketches served an explanatory role for the other team members, enabling the team's transgression into further explorative sketching. The important advantage was that creating the animation-based sketches of the interaction design enabled the fast exploration of a wide range of concepts.

Despite its non-interactive nature, the use of animation in temporal sketching provided viable insights into the interaction possibilities and possible breakdowns implicit in the non-idiomatic technology of augmented reality. It was evident that in watching the animations, different team members noticed different elements from the perspectives of their respective domains. The zoo personnel noticed that having the guest standing in front of a camera at specific places in the zoo might affect the 'rush hour traffic' of guests and potentially disturb both the users of the app and other guests. On the other hand, the developers saw potential usability issues concerning visibility and feedback if no physical constraints were imposed on the context of the app. Although the observations were different, they were based on the same temporal information. As a result, it was easy for the group to communicate, to gather the inputs and to prioritise them with the animated sketch as a frame of reference. This meant that the team members who did not have technical domain knowledge could participate in the interaction design by discussing a narrative about the concept: they did not need to understand the technical constraints in detail. The team members would pause and rewind to certain points of interest; here, they would ask questions and give feedback, which initiated the consensus process among the team. The non-interactive aspect of the animation helped the team to maintain its explorative focus instead of becoming didactic; in other words, this was a sketch rather than a prototype.

One recurring topic of debate concerned the effect the proposed interaction designs would have on the interior decoration of the zoo context. The designers in the team proposed to design visible information posters, light spots on the floor to indicate where the user could use the app, and movie scenography as the context for use of the app. The zoo stakeholders, on the other hand, wanted to keep the physical settings as authentic as possible, without posters and other elements distracting attention from the zoo context. Again, the initial sketches provided insufficient information to reduce uncertainty about the most viable path to take. Instead we had to generate more information about the dynamics of the context, combined with the dynamics of the digital system.

We made an animation-based sketch which combined elements from the sketches into a representation of the use context in the zoo. Animation approaches and visual modalities were mixed via stop-motion, key-frame animation and live video footage. Having recorded a video of two children visiting the zoo and having bodystormed how to use the app, we edited our animated content and interaction sketches into this footage. We took pictures of the aquariums and made them into scenography backdrops, mounted a flashlight to act as a spotlight, and used a series of printed icons as guiding signs. The final video scenario consisted of a brief narrative recounting the children's visit to the North Sea Oceanarium.

Figure 75: The user scenario sketch, combining video footage, mocked up scenography and interface elements, to sketch how the physical context of the zoo could be integrated with the digital design. See the sketch at https://goo.gl/Pv5tKT

The sketch evolved into a short narrative set in the zoo context. The uncertainty about the extent to which the addition of scenography would affect the look and feel of the context could now be addressed temporally and visually through the animation-based sketch. The zoo personal conceded that some background scenography might be useful to support immersion, provided it had the same realistic appearance as the digital content. The developers were also concerning about the extent to which posters and spotlights would be allowed to stand out from the more natural-looking setting of the rest of the zoo. A consensus was reached limiting the guiding signs to a single signpost at the entrance to the zoo, and the augmented reality spots were indicated by unobtrusive footprints painted on the floor.

This scenario facilitated consensus between the team members by representing temporal aspects of the design which would have been hard to grasp without a coded version. However, compared to the previous sketches, the sketching process did not involve the same degree of investigative and explorative emphasis in terms of iteration back and forth between different temporal setups. Instead, the process was clearly defined as the generation of temporal feedback about a specific set of uncertainties and their representation in a way to which all stakeholders would be able to relate. The output sketch was thus explanatory and to some extent persuasive, as each scenario argued for a specific proposal.

It is interesting, however, that when the questions asked became very specific and referred to previous questions posed by animated sketches, the creation of new animation-based sketches was less investigative and thus entailed less visual thinking. Moreover, it took considerably longer to decorate the context, capture the material, and edit it together, than we used in the production of the previous sketches. This was in part due to the consistency of visual fidelities in this sketch: by way of contrast with the U-CrAc sketches, for instance, no mixtures of cut out stop motion and live footage were used. The sketch thus evoked a consistent and almost 'real' sense of the context, but at the expense of the investigative and explorative nature of sketching. This application of animation-based sketching happened at a relatively late stage in the design process, when many of the non-idiomatic aspects of the mobile app itself had been explored. It might therefore be argued that the process had simply reached a stage where the sketching activities had gradually begun to transcend into more specific issues to be tested by producing the actual elements.

Persuasive sketching to inform technical platform constraints

After consensus had been reached about the interior design, and after the transition to development of the first technical prototypes of the augmented reality app, the team began to reduce the complexity of the information that sketching had generated about the design concept. This process followed the traditional iterative cycles of testing, refining, and testing again (Boehm 2000).

As the functionality and content began to take shape in the coded iteration, the developers came to the conclusion that not all features of the app would be able to run fluently on iOS devices. Almost all devices running the Android OS would be unable to render the superimposed augmented reality effects in real time; they would have to record the scene and then render the effects for about one minute.

This created much debate in the team and in the organisation itself. The organisation wanted the mobile augmented reality experience to reach as many guests as possible, while the design team feared that a wait of one minute would affect the user experience negatively. The only thing we knew for certain was that we would have to compromise on the final polish of the iOS version if we had to build a functional Android prototype, When no consensus could be reached on whether to carry on with the Android version, we conceived the idea of using animation-based sketching to reduce the uncertainty about this 'one minute waiting experience'.

We generated the sketch by filming an action video in context and then combining it with a key-frame animation of one of the augmented reality scenes. This scene was followed by a new key-frame animated interface of a load screen, which ran for one full minute before presentation of the augmented reality content. This was the fastest specific animation-based sketch the team created; due the established pipeline of live-video material and content from previous stages of the project, it took no more than 10 minutes to produce.

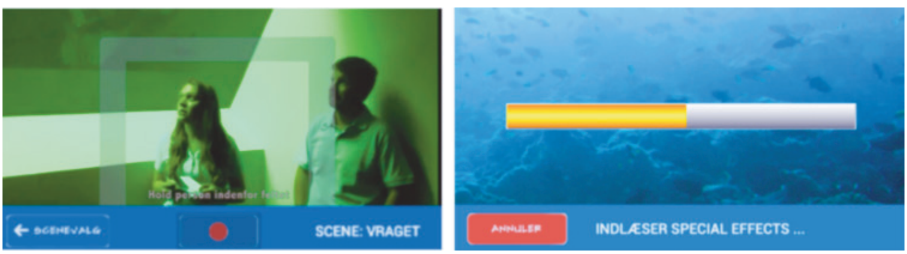


Figure 76: The interface of the app's camera viewfinder is animated on top of video footage from the zoo to illustrate how the user records the scene without live effects (left). The scene is followed by a key-frame animated load screen, running for 1 minute before it presents the recorded scene with the augmented reality special effects (right). See the sketch at https://goo.gl/EHjts1

We placed this video on a smartphone and used the sketch in combination with a Wizard of Oz (Buxton 2010, Kelley 1984) setup, in which the same actors played the same roles in front of the same aquarium. In this way, we emulated the entire user situation and observed the feedback from stakeholders and users when they had to wait one minute before any action happened in the app. Unsurprisingly, the wait was negatively received; most people actually thought that they had waited for more than one minute.

Due to the feedback from this sketch, the decision was reached not to realise an Android version of the first edition of the app. This decision saved enough of the budget to allow the purchase of a series of iOS units to rent out to guests who did not have an iOS device, enabling all guests to enjoy the full augmented reality experience if they so wished. The primary role of this late animation-based was persuasive: it was aimed at providing evidence for the negative effect of load times on potential user experience. On the other hand, in terms of exploring the non-idiomatic technology of this type of augmented reality, the sketch also provided the design team with new exploratory knowledge about the limitations of this type of technology across different platforms.

This illustrates how animation-based sketching can take on different sketching functions over time, as was suggested in part I.

LESSON LEARNED:

Animation-based sketching is ***not an isolated approach for the early design*** phases. Even at a late stage and well into development, it is a way to reduce uncertainty about temporal dynamics which are unpractical to create by other means.

CASE 2: EXPLORING MOBILE GAME DESIGN WITH AN AGENCY

The North Sea Oceanarium case provided an industry perspective on animation-based sketching used to explore the dynamics of the interactive elements of augmented reality. It has shown how the sketches facilitated consensus. Our next industry case sought to combine this perspective with the lessons learned from the workshop cases by exploring how an agency of professional designers would employ the approach. We did this together with the marketing and design agency 'Tankegang' in an exploration of the possible user experiences of a new mobile game. The game aimed to create awareness about recycling and its environmental impact on citizens. The project was entitled 'Recycling Animation' and was organised as an internal R&D project to produce understanding of the non-idiomatic aspects of a new game design model combining elements of augmented reality and the endless runner genre. The app allowed the user to capture him or herself with the help of a mobile camera. This image was used in the game as an avatar. The user avatar was involved in recycling different kinds of incoming garbage at an increasing rate until the user inevitably failed and received a final recycling score. The non-idiomatic elements of the game included the way in which the augmented reality effects functioned alongside the game mechanics, as well as the way in which the user avatar would behave during the game in order to make it fun to 'play as yourself'.

The design process started with a series of user studies conducted in-house by the agency. Through these studies, we learned how the target group understood recycling and related to it in their daily lives. On the basis of these insights, a design workshop was conducted. During the workshop, a series of different concept ideas were conceived and sketched as rough static paper sketches. From these sketches arose the overall concept of a game design with the user in the role of main avatar. However, the sketches only vaguely described how to achieve this and barely touched upon the interaction design of the game. The team soon realised that it was difficult to discuss these dynamics on the basis of static imagery alone. This led to the introduction of animation-based sketching in a rapid, three-hour hands-on seminar. The design team were already proficient in a variety of graphical design tools, such as graphical design in the Adobe Creative Suite, and in using basic video editing skills in various production environments. Thus, we focused on showcasing how their existing tools could be applied in animation-based sketching with the addition of just a few new features, techniques and approaches.

A delicate balance of not asking too many questions at once

With the introduction of animation-based sketching approaches, the designers at the agency started exploring the dynamics of the variations of the game concept. The process here resembled the process we had seen previously with our design students; they starting by creating a series of animatics of the user scenario (figure 77).

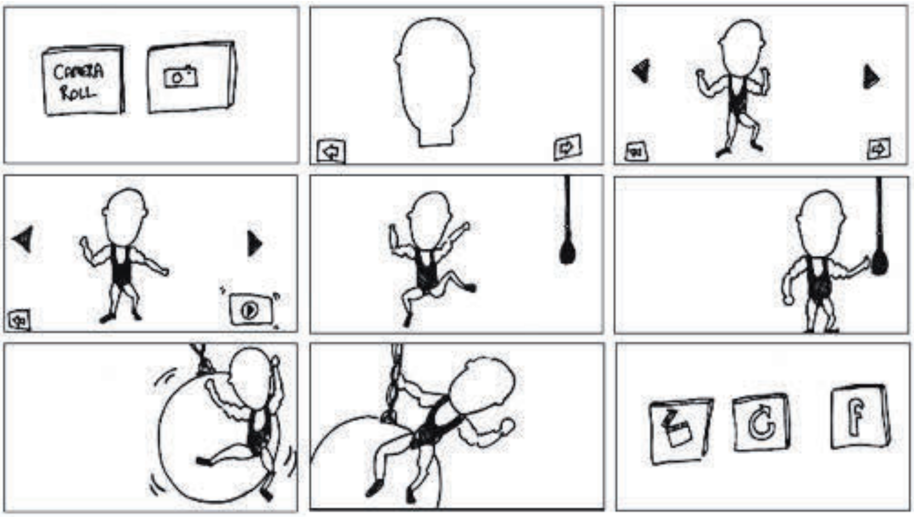


Figure 77: The first animatic adding timed sequentiality to the static sketches expressing the idea of bein able to capture the users face to be used in the game. See the sketch at https://goo.gl/iy1JS7

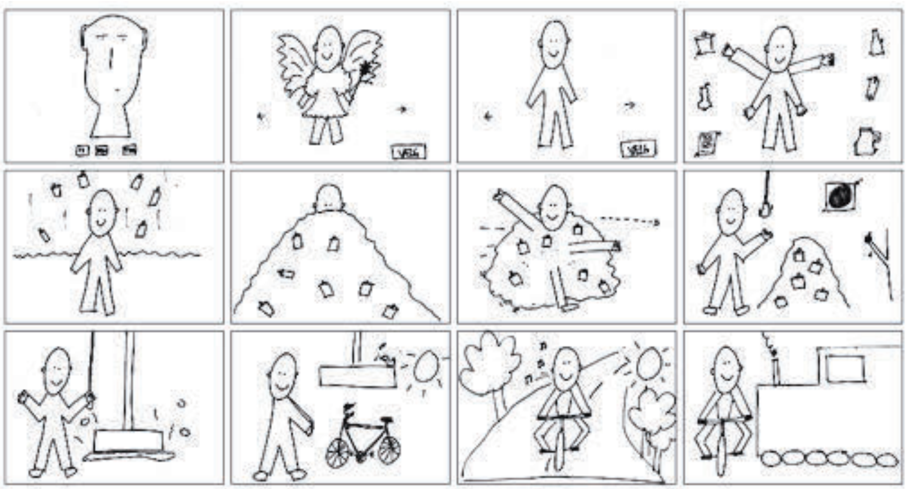


Figure 78: The second animatic took on a higher degree of details in the static sketches, which in turn made the animatic more expressive, and detailed enough to get a sense of how the capturing mechanism and selection of avatar details might work in the concept. See sketch at https://goo.gl/RQCwCf

Completed in less than two hours, the first animation explored a variation of the game in which the gameplay elements were limited to manipulating the user-generated avatar through exaggerated rag-doll physics inside a recycling facility. In the end, the user would be able to share the most entertaining moments of manipulating the character on social media. While creating the sketch, the designer primarily investigated the dynamics of how users would be able to capture themselves for use in the game, and specifically how to create appeal in the game avatar by using the user's own face. However, the specific game elements were only added as an afterthought - a secondary question posed in the sketch. In watching the sketch with the rest of the agency, it became evident that the two questions posed by the same animatic gave rise to an unclear discussion. The primary question, the appeal of allowing the user to act as avatar, was largely overshadowed by the game elements.

What was shown to be at play at this step was Lawson's (2006) point that one should avoid suggesting answers to questions not under consideration at the moment. This might be even more problematic when assessing 4D sketches such as animation-based sketches. When examining static sketches or individual stages in a static scenario, we are free to focus our perception on certain elements for as long as we need. When presented as a 4-dimensional sequence, the represented flow is over before it has been played, creating the need to actively rewind or repeat the sequence to allow space for longer reflections. This creates a perception of the animation-based sketch as the sum of temporal information, whereas static sketches are perceived in their individual stages.

LESSON LEARNED:

Temporal information is needed to inform the dynamics of non-idiomatic aspects, but ***the risk is that too many questions may be posed to be comprehended at once.*** In effect, the information generated raises the complexity faster than the uncertainty of the design possibilities is reduced. This is a crucial lesson concerning animation-based sketching.

Animatics - getting a sense of the appeal in the game

On the basis of these observations, we proposed that the designers should narrow down the problem setting to a more focused investigation of how to make the game more appealing.

The designers created a series of very simple and fast cutout animations by merging the faces of each member of the design team with the body of another member. The resulting bodies were animated in a variety of distorted poses using stop motion and manipulations.

Figure 79: These sketches used stop motion with cutouts of photographs to explore the how to distort the user avatar in humorous ways. See at https://goo.gl/UFbY3r

In examining these sketches, the designers adopted the evaluative criterion of whether their colleagues laughed on seeing the distorted avatar being manipulated. On the basis of these reactions, further poses and examples were created - from investigative to explorative animation-based sketching. The next step was to ask whether this type of rag-doll physics would create the right appeal in the context of a recycling facility. The designers thus created a quick scene depicting a factory workshop, took the ideas from the cut out animations into an animatic with relatively high visual fidelity, and sketched a scenario with the avatar inside the factory.

Figure 80: Based on the previous cutout animation, an animation-based sketch was made digitally to explore the mix of visual fidelities, and how the distorted user manipulations would behave in such contexts. See sketch at https://goo.gl/LlzCAe

These animation-based sketches were clearly narrower in scope and did not present the dramatic discourse of the previous animatics. On the other hand, they did represent a much more focused explorative sketching effort, in which the sketches facilitated a focused discussion about the appeal of the proposed idea of placing the user’s face on the avatar. The output was a decision to explore the branch of these user-generated avatars further and to broaden the problem setting to explore how this avatar would interact with the recycling workshop.

Animating interactive game behaviour

Neither the animatics nor the focused avatar cut-out sketches included temporal information about the specifics of how a game could be played with the user-generated avatar. The idea proposed involved merging rag-doll physics, the user-generated avatar, and the genre of 'endless runners'. A few static sketches were made to visualise this idea, and the agency tested a series of existing games from the genre to learn from best practices. It was evident, however, that the patterns of existing games did not make it much easier to assess the entertainment factor provided by the game mechanics and by the fact that the users appearance was transferred to the avatar . This seemed to be the natural point of transition into interactive prototyping to test the combination of these elements. However, the agency developers noted that a prototype would require them both to develop a working version of the endless runner game and to develop the capturing engine to capture the user's face . The R&D budget limited the feasibility of creating this comprehensive coded version, especially if the idea were to prove unsuitable. Thus, the designers spent a day creating a series of animation-based sketches by reusing the graphical components from the user-generated avatars and applying them in variations of animated user scenarios of the full game experience from a natural discourse.

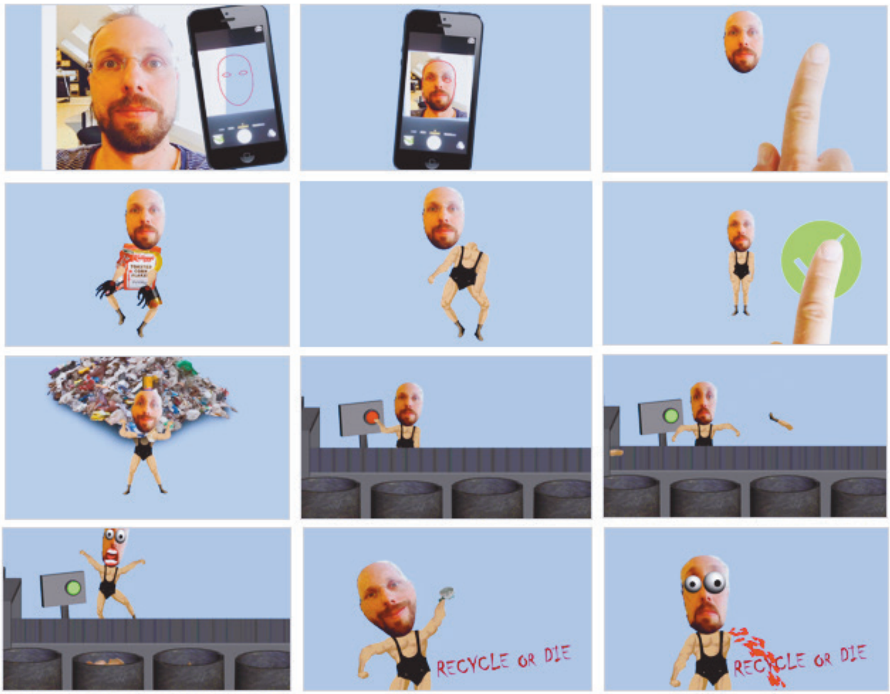


Figure 81: The last animation-based sketch explored the full user scenario in high visual and temporal fidelity, to also gain feedback on the finer dynamics of the end-less runner game mechanics. See sketch at https://goo.gl/o2V2Kb

The intent behind the sketch was that it should allow the team to cooperatively explore the flow between generating the user avatar and using the avatar in a recycling themed endless runner. These sketches had a significantly higher temporal fidelity than the previous sketches, where the designers even experimented with simplified applications of physics-based animation principles such as squash & stretch. Even though these principles were applied, the designers were able to create the effect by combining their existing graphical design skills to quickly generate the graphical components. These could then be edited in the animation production environments. The application of principles such as 'squash & stretch' did not look finished or physically correct, but it gave a clear idea about the dynamic relationship between the game mechanics and the avatar in the variations of the ideas animated.

These animation-based sketches later assumed an explanatory sketching function; they were shown across the agency to other employees, who provided further responses, comments and reflections upon the information generated from seeing the sketches. The important point here was that the previous animatics and cut out stop motions had asked the important initial questions, thus enabling the new animated user scenarios to include both what had already been decided and variations of the new questions. In this way, the sketches portrayed a clear constant in terms of the appeal of the user-generated avatar and proposed clearly articulated questions regarding the game dynamics and interplay with the avatar. This established a basis for assessing the potential of the different game designs and supported the gradual transition into the actual development of game elements based on the reflections about the animation-based sketches. In fact, the developers used the animation-based sketches as the base component layer in their initial work on creating the first interactive prototypes. In doing so, they used the same graphical components and animations but added simulative input and output. In effect, the animation-based sketch as an emulator transcended into an interactive simulator.

> **LESSON LEARNED:**
> The time and care invested in creating animation-based sketches in the later phases of design can actually be recouped in the design of the equivalent graphical and temporal aspects of subsequent development.

WHAT ABOUT THE INDUSTRY?

We now leave our own work behind and broaden the scope outwards to wider industry perspective. The ambition behind this book was never to claim to have discovered animation as design material. As we have showed in the reviews in Part I and Part II, many previous contributions have paved the way to indicate both the potentials and pitfalls of using animation in the early design process. Not all of these are strict academic research contributions, but intriguing examples of companies and organisation experimenting with animation in their own design processes. Many of these contributions never reach the outside of the R&D departments the companies, and thus it is hard to make a qualified guess of, how many companies have experimented with the approach in industry.

In recent years however, the rise of social and viral mediums such as Facebook, Youtube and Vimeo have given rise to a steady climbing amount of industry animation-based sketching reaching the public. By realising short videos which often employ animation to represent an idea for an idea of a future use of given technology, or a novel interaction with existing technologies, companies generate buzz and gain attention before the product has even been developed into a technical prototype. While the sketching aspects of some of these ‘vision videos’ might be questioned in the same regard as the previously mentioned Apple Knowledge Navigator and Nokia Vision, these video does indicate an industry interest in experimenting with the qualities of animation in the early design process. Furthermore, when examining the industry contributions, a large portion of them actually do show the uncertainty reducing qualities we have come to associate with sketching.

In the introduction chapter of the book we briefly introduced Jaguar and their ‘Virtual Prototype in Testing’ video. However, Jaguar Range Rover is only one of an increasing amount of big corporations applying animation to portray their future vision scenarios on web 2.0 media. Below we will briefly introduce two rather different industry cases of using animation what fits our definition of animation-based sketching.

FireFox - explorative sketching of a new user interface paradigm

When Microsoft released its then new operating system Windows 8 in 2012, it brought about the most radical shift in user interface paradigm in many years, the design language called ‘Metro’ or ‘Modern’. This challenged many software companies to redesign their Windows applications to adhere to the new user interface paradigm. The user interface paradigm was aimed at being useable on both desktop and mobile platforms, and utilised more flat and layered interface than seen before - in essence the paradigm was non-idiomatic.

Mozilla, the company behind the popular Firefox web-browser detailed their challenges with creating a browser interface for this non-idiomatic interface paradigm, and reckoned that especially the flow in the interface was a challenge. User Experience Designer at Mozilla Yuan Wang showed how she used the consumer grade simple slideshow software ‘ Apple Keynote’ to animate a series of explorative sketches for the User Experience team a Mozilla to assess.

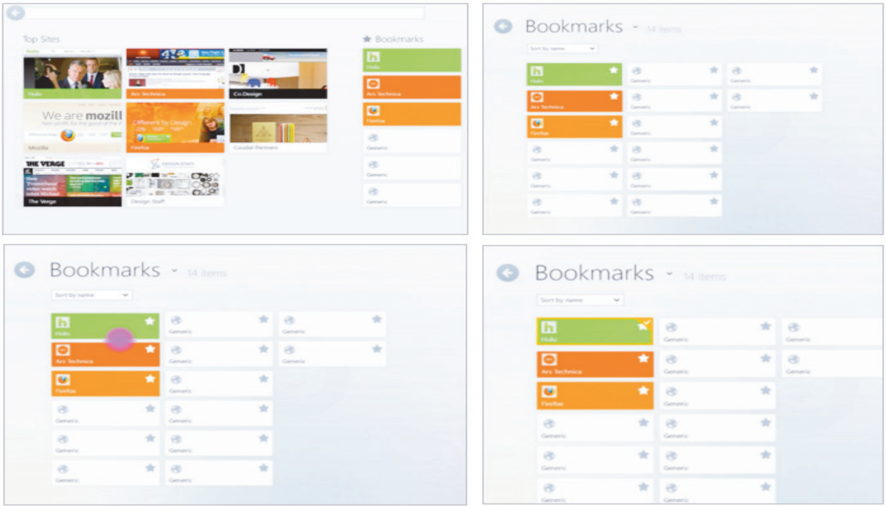


Figure 82: Stills from the Keynote animated sketch of the Windows 8 version of Mozilla Firefox. See the sketch at http://goo.gl/sZ4iXs

The sketches take on an isolated interface & artifact interaction perspective with an instructional discourse, and clearly has an explorative and explanatory intent. The exploratory aim is evident in how the sketch proposes different flows and ways of interacting with web-content, which other peers comment on in the comments section of the description. The explanatory function lies in the public nature of the sketch being placed on the online video service Vimeo, and shared on the Mozilla Blog for showing Mozilla's vision for handling the Metro design paradigm. This animation-based sketch is an example of a very common genre of industry sketches made available to the public. These sketches balance between communicating a preview of how the future interfaces of the product might be, as well as utilising the dialogue and feedback from the users in what can essentially be understood as a way of co-creating the concept - although in an crowdsourced manner.

Google Glass - between exploration, explanation and persuasion

When Google in 2012 announced its much hyped 'Project Glass' it created an overnight interest in augmented reality. The vision was to integrate the functionality of the smartphone into a digital layer of the users vision, being constant available and customised to a given context and situation. Even though the Google Glass was closer to being ready for public showing than the Land Rover concept, Google did not have a functional version of the Glass ready when announcing the concept. Instead they presented a compelling video scenario called 'One Day' , which showed a day of using Glass (figure 83).

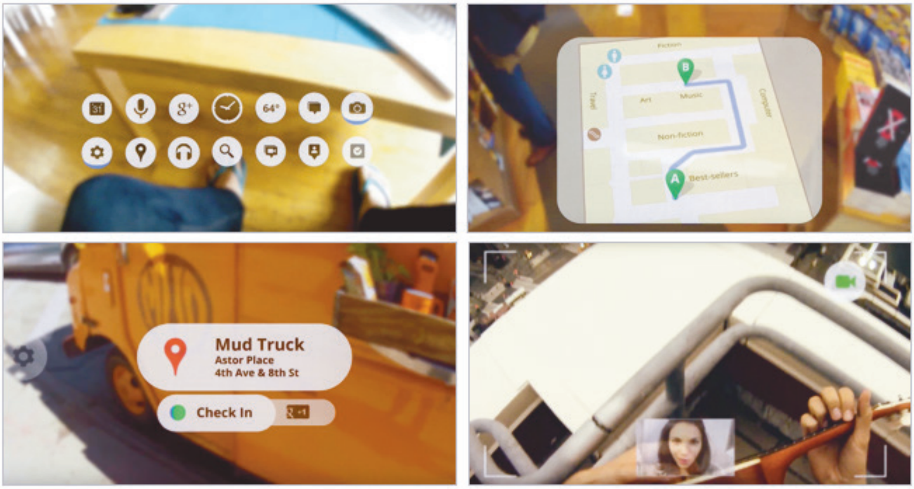


Figure 83: Stills from Google's animation-based introduction to the Project Glass 'A Day with Glass'. See the video at http://goo.gl/OKKZbA

In the video, the augmented reality layer is animated to show different features, such as navigation, voice recognition, location tagging and instant access to the camera. What is interesting is how the video uses animation-based sketching in much the same way as we saw with Land Rover - to create hype and suspend disbelief about this science fiction like product. Likewise, the massive press coverage, blog comments, and user interest created a large amount of reflection, critical blindspots and questions, which Google could leverage in their ongoing development of the Glass concept - a lot of which showed to be included in the first functional test prototypes sent to lead users. Again this qualifies the video as being more than just a vision - a sketch which proposes how things might be with the technology Google were on the verge of unleashing to the public.

However the Google Project Glass sketch also shows one of the risks of using such high quality animation in an animation-based sketch of a technology which is not years, but only months away. When the first Glass prototypes reached users, it was soon evident how the user interface and visuals of the augmented reality was subpar to what had been shown in the animation-based sketch. The original 'One Day' video did not use any actual interface footage, but animated the elements with an explanatory intent, distorted to make it easier to perceive without actually trying it yourself. This approach works well when dealing with more rough visual and temporal fidelity, where there is little doubt that the represented is not a finished system, but a sketch exploring the dynamics of what could become real. With the Google Glass, the initial animation-based sketch created more promise than the prototypes could deliver. In a sense, Google fell into the trap of realising the hyperrealism promise of orthodox animation - being more expressive than reality itself.

The project Glass sketch serves to show how animation-based sketching is an approach which holds a potentially great rhetorical power. Animations of how a proposed technology can be utilised to create a compelling user experience, and in doing so both investigate, explore and explain the potential of the non-idiomatic technology. But due their narrative sequentiality they are also always persuasive to some extent, and when done with a clear intent they can create very compelling and persuasive arguments. This presents the designer with a responsibility of not promising more in an animation-based sketch, than could possibly be executed in reality - that is unless the aim of the project is to actually explore speculative designs (Dunne & Raby 2013). This is why Buxton's notion of leaving ambiguous holes in sketches (Buxton 2010) are also as, if not even more, important to animation-based sketching. Animation-based sketches should invite the viewer in, presents its proposal, and then let the viewer go on to make their own critical reflections on what they saw. If not, the sketch takes the risk of presenting either blown up visions, or simply promising never realisable *'vapourware'* (Sterling 2013).

TEMPORAL INFORMATION - AN INCREASING INDUSTRY NEED

In this chapter we have discussed a range of perspectives on how industry actors either have used animation-based sketching or through our interventions have experimented with using the approach in their design and innovation processes. The included examples cover only a small fraction of the examples available from companies around the world. The examples are not only from high tech IT companies, but also covers e.g. future home visions from IKEA (see more at goo.gl/EowRvt), as well as the range of innovative ideas on crowdfunding sites like Kickstarter and InDiGoGo, which often start their life cycle as nothing more than animation-based sketches.

What this shows us is that the industry, much like the previous research contributions, has an interest in the potential of using animation to represent the dynamics of their ideas for future uses of emerging, and often non-idiomatic, technologies - however without much reflection on the broader strokes of what constitutes the approach used. What the industry perspectives from our own design initiatives also indicates is, that there is a potential of using simpler and faster animation-based sketching in the earlier phases of research & development or initial ideations of design processes concerning non-idiomatic technologies. In this regard, the potential is known and industry incentive exist, and what we have shown is, that animation-based sketching is broad approach, applicable in varying fidelities as well as in various points in the design process.

LESSON LEARNED:

The industry has to some degree already experimented with using animation-based sketching approaches - at least as a means of visual communication - which indicates a recognition of the potential of using animation to represent the interaction design and user experience of new digital systems prior to development.

This concludes our dissemination of the current state of both our own, as well as the industry's application of animation as sketching capacity in the exploration of fictional, but potential, realities, used in to facilitate the design process of them becoming factual.

THE END

We have now reached the end of this book. Through descriptions, analysis, and discussions, it has positioned animation-based sketching as a distinctive design approach that generates temporal information to reduce uncertainty about the dynamics and potential user experience of non-idiomatic technologies. The ambition was to address this ambiguous phenomenon by building a stronger basis for fitting together the concepts of design sketching, interactive technologies, animation and facilitation in a unified approach. We have attempted to show how animation-based sketching draws on the theories of design sketching, animation studies, digital media and computation. It is our belief that a strong foundational knowledge of the history, discourse and traditions of a domain is important when establishing a distinctive phenomenon. We have contributed to the existing discourse about the use of animation in design sketching in this regard, uncovering some of its roots and organising them to assist in the definition and ontology of animation-based sketching

We have defined animation-based sketching as the use of animation to portray a fictional proposed reality that is intended to become factual. This is achieved by emulating the simulation of a bounded model of reality in digital systems. It follows that animation-based sketching has a digital sketching capacity, in light of which we have discussed the archetypical perspectives, narratives discourses, fidelities, and functions the sketches can have. We have seen these features manifested in a range of different contexts, ranging from our constrained workshop experiments to constructive collaborations with stakeholders outside academia. From these efforts, we have derived a series of lessons learned about the viability and practicalities of applying animation-based sketching as a design approach in practice.

Here, as the book is drawing to a close, we argue that animation-based sketching has significant potential as a tool for design. By creating the illusion of apparent motion and change, designers can emulate complex dynamics and interactions involving new non-idiomatic technology, and represent it in interplay with users as contexts. This enables designers, stakeholders, and external recipients to reflect upon the proposed idea from a perspective in which the technology seems already to be in use, already implemented, with a proposed user experience. Nevertheless, it is ambiguous because it is unfinished. We have seen that temporal information may provide value in terms of informing us how a proposed user experience may be realised in practice and that animation offers a way of assessing the utility, usability and desirability of new technologies before costly resources are spent on prototyping or on actual development. The animation-based sketch offers an unfinished proposal which asks questions, inviting others to reflect upon whether the proposed idea is a desirable future state of the world.

However we have also seen examples indicating that animation-based sketching is not a 'jack of all trades' approach and that ill-considered applications might lead to undesirable design processes. This happens when the craft of animation takes over from the craft of design sketching, animating something which looks like sketches rather than actually sketching with animation. We have sought to show these risks by drawing on practice as well as on our analysis of the principal production environment features needed to enable animation-based sketching. Animation-based sketching is not just about using a specific tool, technique, material, or narrative discourse. Rather, the success of animation-based sketching depends on balancing the digital sketching process with the appropriate visual and temporal fidelity needed to pose the right questions at the right time in the design process. Through animation-based sketching, the designer creates a problem setting which should be wide enough to facilitate reflection but narrow enough not to pose too many questions at once. Whether used to investigate a design problem, to explore possible solutions, to explain an idea to peers, or to attempt to persuade a stakeholder about the viability of a specific idea, animation-based sketching provides the information needed about the non-idiomatic dynamics of the proposed design.

This is our contribution to the positioning of animation-based sketching as a distinctive design approach; animation-based sketching makes it viable to generate information about the temporal dynamics of a proposed system, thus reducing some of the uncertainty about the potential of new non-idiomatic technologies.

The next horizon for animation-based sketching?

We framed this book to deal with sketching the user experience of non-idiomatic technologies. This was partially due to the natural limitations of traditional static sketching approaches in this domain. However, the framing of this subject matter was also determined by the fact that previous studies of the use of animation for sketching almost solely originated from within the interaction design and human-computer interaction field in academia. We continued along this road, discussing how animation emulates digital simulators.

However, limiting the potential of animation-based sketching only to the domain of interactive digital technologies would involve giving the approach too little credit. Other domains might also potentially benefit from the generation of temporal information through animation. As it is, we have already seen some indications of this in our experiments from the U-CrAc workshops, which, at the time of writing this book, have been held seven times. We have focused on sketches sampled from the latest workshops, dealing with non-idiomatic aspects of new digital technologies and services. However, many cases in the workshop have also addressed non-digital issues, such as service design, business model generation, and organisational development and learning, We have observed how animation-based sketching provided valuable temporal information in these cases, creating an overview and transparency for the complex systems and relationships in large organisations, networks and services. On the basis of the insights from this book, it is our new hypothesis that many of the lessons learned about animation-based sketching might also apply to these system level domains and potentially support and facilitate decision-making on a grander strategic level. While this topic is outside the scope of this book, we suggest that this should be the next great venture in the continuing elucidation of animation-based sketching as a design approach.

Part of a larger ecology of renderings

While we have argued the case for the viability and practicality of animation-based sketching in this book, we will leave the reader with a word of caution. A high level of investment in one specific design approach and a commitment to arguing its potential make it easy to lose sight of its place among a larger ecology of rendering types. In the book we have often compared animation-based sketches with static sketches and interactive prototypes. The choice of animation over static depiction depends on the balance between the extra sketching time required to sketch with animation and the temporal information gained by doing so. Animation trumps depiction when there is a need to reduce uncertainty about temporal dynamics. The choice of animation over interactive prototypes in code depends on the balance between (often) faster sketching in animation and the loss of interaction.

The emulative capabilities of animation-based sketching always involve the contingent choice of an approach which may excel in generating information in some cases but fail to do so in other situations. The need to be sensitive to this choice is perhaps the most important lesson to take away from reading this book. Animation has great potential for representing the possibilities of non-idiomatic technologies, and we have argued that this is a potential that has yet to be fully realised. But regardless of the situation for which animation is chosen as a sketching approach, it must be used in a different way than traditional animated film and not become 'the product' in itself. It should be kept fast, rough, and ambiguous enough to be a process tool for reflection upon both problem setting and problem solving within the setting. Only in this way, can animation-based sketching unleash its potential, using animation to portray a fictional reality about a preferred state of the world with the aim of making it real.

That's all Folks!

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SKETCHING WITH ANIMATION

This book offers a contribution to the theory, method and techniques involved in the use of animation as a tool for temporal design sketching. Lifted from its traditional role as a genre of entertainment and art and reframed in the design domain, animation offers support during the early phases of exploring and assessing the potential of new and emerging digital technologies.

This approach is relatively new and has been touched upon by few academic contributions in the past. Thus, the aim of the text is not to promote a claim that sketching with animation is an inherently new phenomenon. Instead, the aim is to present a range of analytical arguments and experimental results that indicate the need for a systematic approach to realising the potential of animation within design sketching. This will establish the foundation for what we label animation-based sketching.

This book is divided into three parts. Part one begins by defining the foundational concepts needed to understand the animation-based sketching of interactive digital systems. We review the state of the art in design sketching, in studies of emerging technologies, and in the field of animation, as well as their potential fit with design sketching. Part two build the argument for definining animation-based sketching as a broad tool-agnostic approach that uses animation to portray fictional realities - but with the aim of realising them as facts. The third part finally turns to the practical side of animation-based sketching. This section draws on examples from praxis and small constructed experiments designed to showcase specifics techniques as well as the design knowledge we might extract from using animation in design sketching. Finally, we seek to assess the role of animation-based sketching as a tool that can inform decisions early on in the design process before more costly resources have to be devoted to development or implementation.